January 2012

Bringing Green Power to Disadvantaged Communities

Ashik K. Gowdar
Worcester Polytechnic Institute

JRK 1002

BRINGING GREEN POWER TO DISADVANTAGED COMMUNITIES

An Interactive Qualifying Project Report

Submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

by

Ashik K. Gowdar
ashik_gowdar@wpi.edu
WPI Box# 3445

Date: January 9, 2012

Advisors:

Professor Robert Krueger
Assistant Professor, Interdisciplinary and Global Studies
Director of Worcester Community Project Center

Professor Fred Looft
Professor and Department Head, Electrical and Computer Engineering

Abstract

This project examines the U.S. Environmental Protection Agency's RE-Powering America's Land initiative and seeks to demonstrate a strong future for siting renewable energy resources on brownfield sites. The project also explores the Environmental Justice Movement and argues for inclusion of environmental justice principles in the RE-Powering America's Land Initiative. Finally, the project presents case-study of a brownfield site at 95 Grand Street, Worcester, MA and applies information presented in the project to the site, providing guidelines for implementation of a renewable energy development project.

Table of Contents

Table of Figures and Tables

1. Introduction

Electricity is one of the indispensible needs of human life today. It plays a vital role in virtually every residential, commercial and industrial activity. Abundant and unlimited access to electricity is a key factor in improving a nation's economy and the quality of life of its people (National Academy Press, 1986). Most countries today are striving to generate low cost electricity in a sustainable manner. But due to present dependence on fossil fuels for electricity generation, electricity prices have been steadily increasing in the past decade. Many experts have noted that development of renewable energy is vital to sustainable future development.

In September 2008, the U.S. Environmental Protection Agency (EPA) introduced the RE-Powering America's Land Initiative. The initiative seeks to site renewable energy resources on former contaminated sites like abandoned factories, landfills, mine sites, brownfields, etc. Such development of renewable energy on contaminated sites offers two benefits- increase in the amount of renewable energy produced in the nation and stopping urban sprawl by utilizing previously unusable land.

As EPA's RE-Powering America's Land Initiative seeks to redevelop contaminated properties, Environmental Justice in low-income and minority communities is an important consideration. Low-income and minority communities have long been targets of environmental injustice and adverse effects of hazardous waste disposal (United Church of Christ, 1987). But the RE-Powering America's Land initiative does not mandate project developers to distribute the benefits of renewable energy development on brownfields in the surrounding low-income and minority communities. This project argues for the need for environmental justice polices in EPA programs like the RE-Powering America's Land Initiative.

Chapter 2 of this project introduces the U.S. Electric Power Grid, its current state and the future of the grid. The chapter aims to demonstrate a trend towards prominence of renewable energy resources. Chapter 2 of the project deals with brownfields and RE-Powering America's Land Initiative. The chapter defines a brownfield, discusses advantages and challenges of redeveloping brownfields, introduces legislature related to brownfields and details EPA's RE-Powering America's Land Program. The goal of the chapter is to demonstrate the potential for siting renewable energy on brownfield sites. Chapter 4 discusses the Environmental Justice movement and its relationship with the RE-Powering America's Land Initiative. Chapter 5 develops a case-study of a brownfield site at 95 Grand Street, Worcester MA to relate information discussed in the previous chapters to a real world situation. Chapter 6 summarizes and concludes the project.

2. U.S. Electric Power Grid

The U.S. electric power grid is an interconnected network delivering electric power from suppliers to consumers. Three distinct operations are an integral part of the grid- electricity generation, transmission and distribution. Electricity generation takes place in power plants located in proximity to energy resources such as coal, natural gas, hydropower, etc. Power plants usually have very large generating capacities to take advantage of the economy of scale. The generated electricity is then transported over long distances to sub-stations near populated areas through transmission lines. From the sub-station, electricity is supplied to the end user through a local distribution grid (Tester, 2005).

The electric power grid is one of the most remarkable engineering systems that affect virtually everyone in the United States. In fact, The National Academy of Engineering in fact voted electrification brought about by the grid as the greatest achievement of the 20th century (National Academy of Engineering, 2003). The grid was instrumental in promoting massive growth in the U.S. economy during the Cold War through mechanization of human labor and it continues to foster economic development. This correlation between economic growth and growth in electricity generation can be clearly seen comparing Fig.1 and Fig. 2. From 1960 to 2010, the US national Gross Domestic Product (GDP) grew from $520 billion to $14.5 trillion while the electricity generation grew from 799 terawatt-hours (TWh) to 4,165 TWh (The World Bank, 2010).

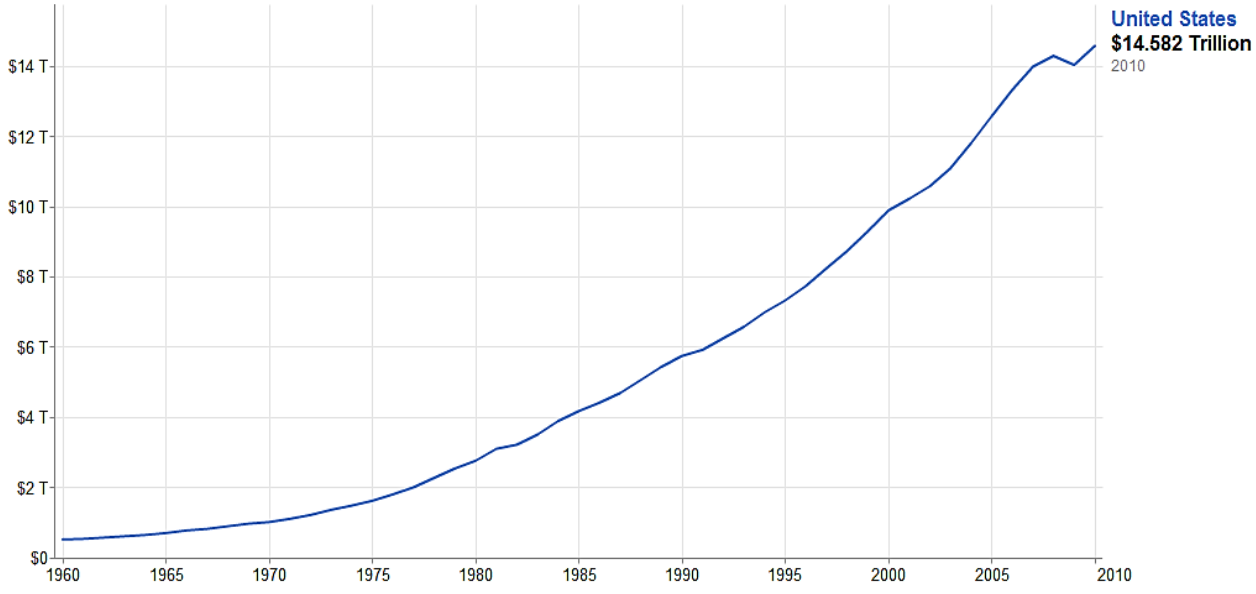

Figure 1-Graph showing the growth of US national Gross Domestic Product (GDP) from 1960 to 2010 (in trillion dollars)

(World Bank, World Development Indicators, 2011)

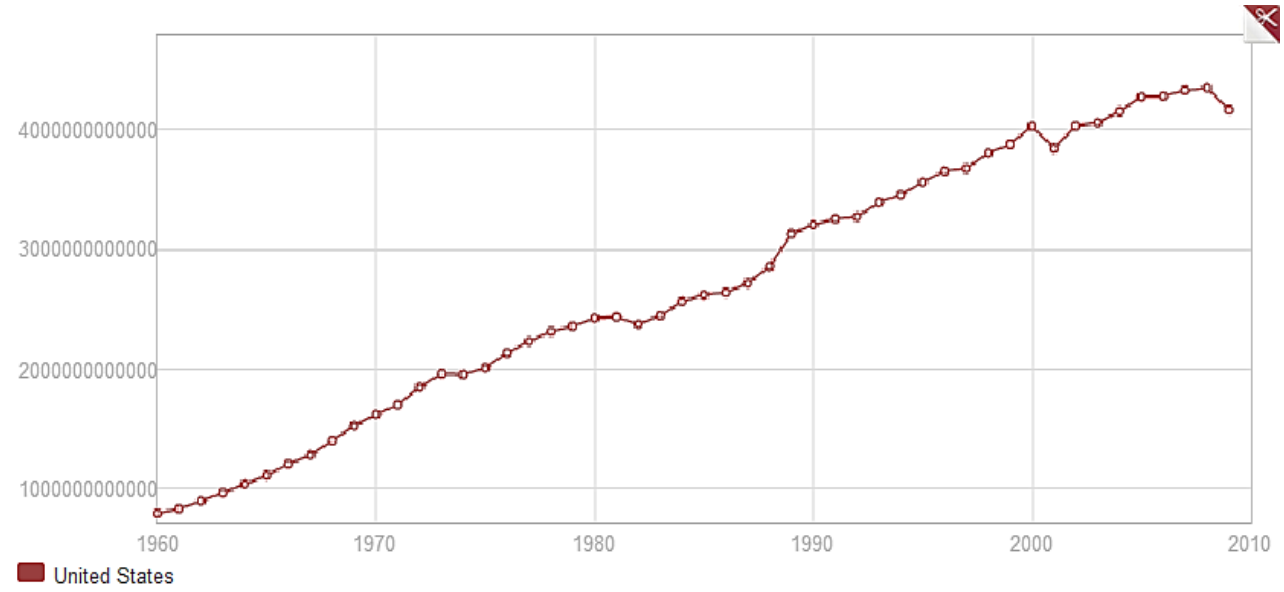

Figure 2- Graph showing the increase in the amount of electricity generated in US from 1960 to 2010 (in kilowatt-hour)

(World Bank, World Development Indicators, 2011)

2.1 History of the U.S. Electric Power Grid

The present electric power grid was built around the beginning of the 20th century to meet the increasing demand for electricity. In the formative days, the electric power industry was vertically integrated. That is, every electric utility owned and operated its own infrastructure from generation to distribution. The industry was also a regulated monopoly, with the costs of the infrastructure being borne by the customers (Tverberg, 2008).

In 1980s, the Public Utilities Regulatory Policies Act (PURPA) signed by President Jimmy Carter opened doors to partial deregulation of the electric power industry (Tverberg, 2008). Electric utilities were mandated to produce or purchase electric power meeting modest efficiency standards. As a result of this law, a free market was created in the electric power industry and Independent Power Producers (IPPs) or Non-Utility Generators (NUGs) backed by private investment flourished. Many utility companies only maintained transmission and distribution grids and bought electricity from IPPs/NUGs. The goal of utilities became making money for its stakeholders (Tverberg, 2008).

The electric utilities which previously operated in isolation found it more efficient to interconnect power plants through transmission lines. This allowed for choices in purchasing electricity to ensure the lowest possible price. With growing demand, more high voltage interconnections were

built to transport electricity over long distances. Eventually, three large interconnected sectors; the Eastern Interconnection, the Western Interconnection and the Electricity Reliability Council of Texas (ERCOT) evolved in the U.S. Figure 3 shows the three sectors and the major transmission lines running between them. This system allowed for the buyer to be geographically separated from the supplier yet receive electricity (Energy Information Administration, Energy in Brief, 2009).

2.2 Current State of the U.S. Electric Power Grid

Since its inception in 1882 by Thomas Edison's Pearl Street Station in New York City, the concept of the electric power grid has largely remained unchanged. The grid functions on the same just-in-time product delivery architecture and has only grown in scale (Electricity Advisory Committee, 2008). Electricity is still produced in large centralized power plants and delivered at the same instant to end users through the grid, with any additional demand met by firing up dedicated 'peaker plants'.

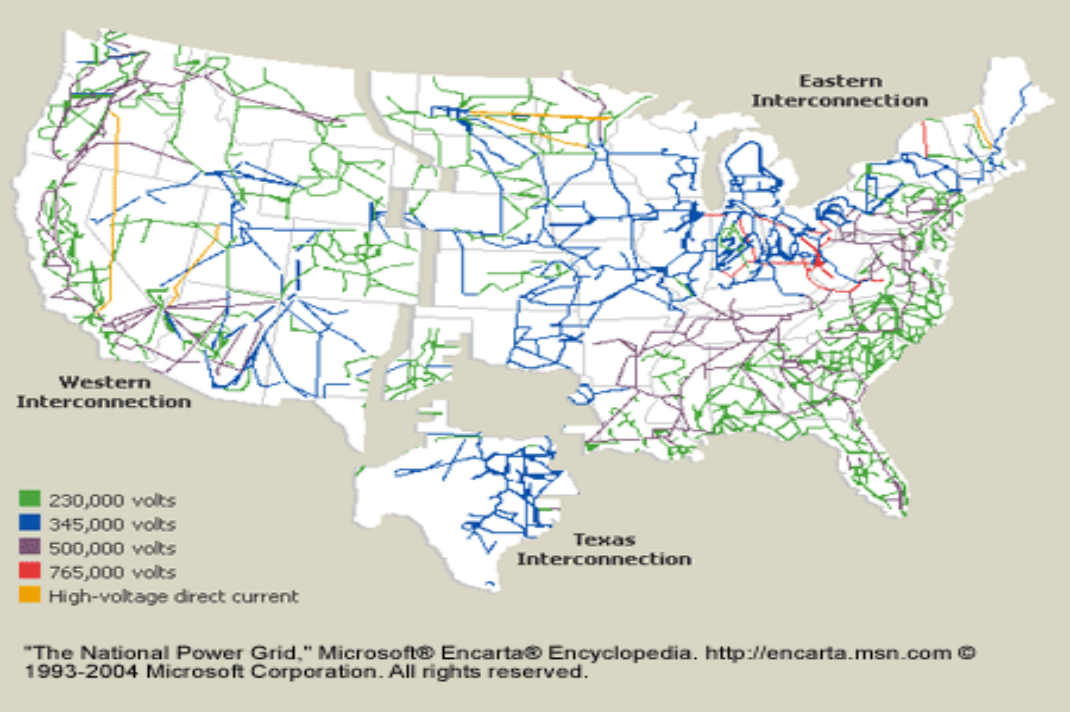

Figure 3- Figure showing the three main interconnections in the U.S. electricity grid

The existing grid was designed to meet the demands of a much smaller population in the 1960s. With increase in population, demand and rise of the digital age, the grid is slowly becoming obsolete (Electricity Advisory Committee, 2008). Recent studies have found concerns in many areas like efficiency, reliability, dependence on fossil fuels, sustainability and consumer engagement. Following is an examination of each of these problems:

2.2.1 Efficiency

Though the transmission grid with three interconnections was an efficient way of delivering electricity when it was "too cheap to meter" (as stated by Lewis Strauss, the Chairman of the US Atomic Energy Commission in 1954), today transmission of electricity over long distances poses a problem. Transmission and distribution losses account for about 7% of the total electricity transmitted in the U.S. which is equivalent to powering 3,97,1143 average American households for a year (Energy Information Administration, Frequently Asked Questions, 2011) (World Bank, Electric Power Consumption perCapita, 2008) (NationMaster, 2008).

The problem of efficiency also extends to electricity generation. About 51% of the current generating capacity is installed in power plants that are at least 30 years old (Energy Information Administration, 2011). The overall primary fuel-to-electricity efficiency for most power plants today is around 30%. As a result, about 26.10 Quadrillion BTU of energy was wasted (out of 38.19 Quadrillion BTU) in the process of electricity generation in 2009 (Lawrence Liverpool National Laboratory, 2009).

2.2.2 Reliability

Reliability is the ability of the electric power grid to secure constant electricity supply at a reasonable price (Alanne & Saari, 2004). A reliable grid is vital in today's digital world for functioning of virtually every aspect of life. From keeping food from perishing to trillions of dollars of stock market trades, today's society is intricately dependent on a constant supply of electricity. Though the present grid is 99.97% reliable, it still allows for interruptions and power outages resulting in losses up to $150 billion every year (Electricity Advisory Committee, 2008). On an average, annually the Midwest and the Northeast experience 92 minutes and 217 minutes of power outages respectively. The Energy Information Administration data suggests that the number of outages exceeding 100 MW has grown by 63 percent and 134 percent more outtakes affect more than 50,000 customers since 2005 (as shown in Figure 4) (Amin, 2011).

The electric power grid is a just-in-time delivery system. Demand and supply of electricity are required to be in a dynamic equilibrium at all times. This is a complex task to accomplish especially during peak periods like a hot summer afternoon. During peak demand, transmission lines get overloaded and are vulnerable to failure. In an interconnected web like the existing grid, a small failure can cause widespread power outages. An example for such an outage is the Northeast Blackout of 2003 (IEEE, 2003). On August 14, 2003 a high voltage power line brushed against a tree and faulted. This combined with the failure of an alarm in the FirstEnergy Corporation's control room caused about 100

power plants in the region to shut down. As a result eight northeastern states and southeastern Canada lost power affecting about 50 million people and caused damages worth $6 billion (Minkel, 2008). Three massive blackouts have occurred in the past decade alone. With ever increasing demand for electricity, stress on the grid is increasing exposing it to more widespread blackouts.

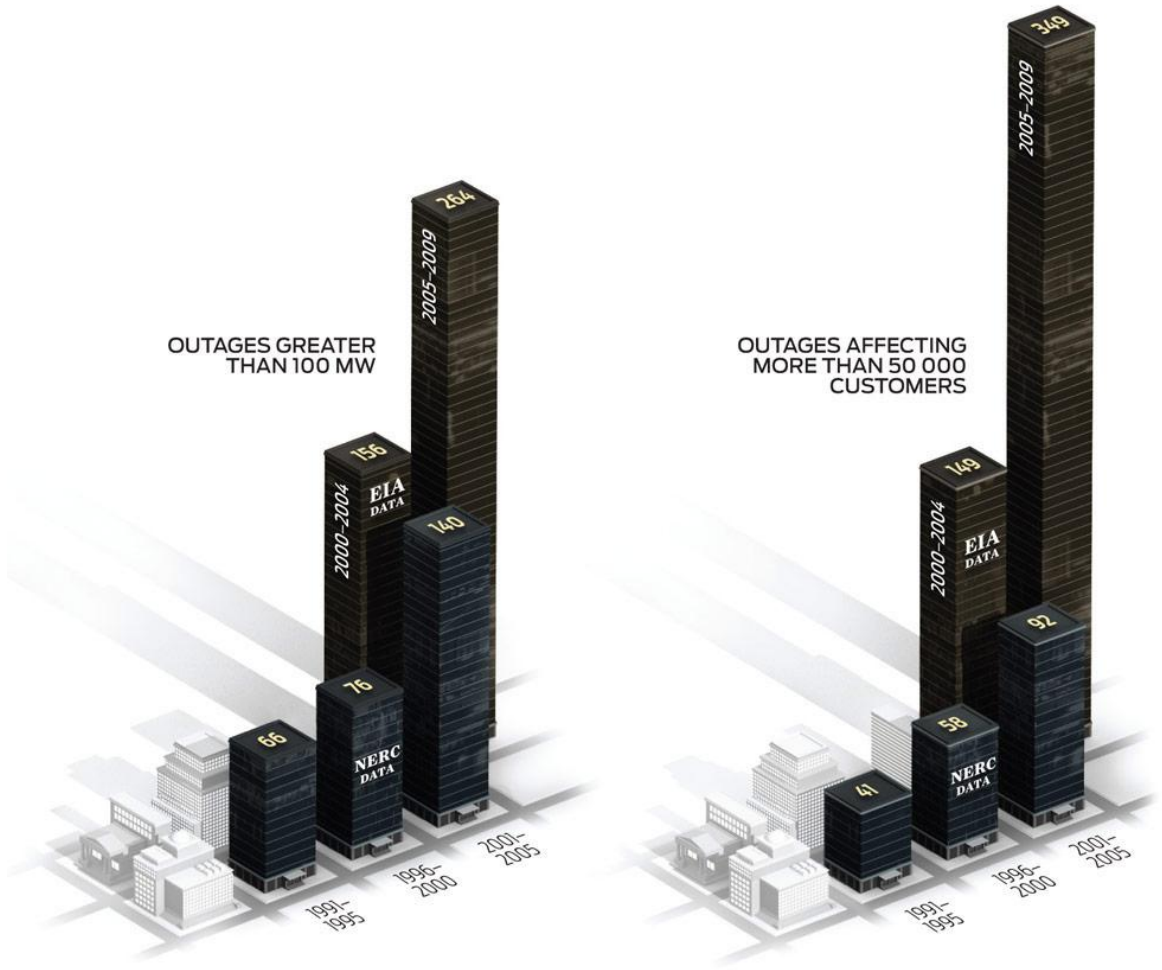

Figure 4- An illustration showing the number of power outages over 100 MW and the number affecting more than 50,000 customers from 1990 to 2011 **(Amin, 2011)**

Adding to the problem is a society exponentially growing digital. Digital electronics are an integral part of virtually every aspect of today's lifestyle. Energy usage by electronic devices is expected to grow three times worldwide by 2030 (International Energy Agency, 2009). By 2015, the share of electricity consumed by electronic devices in the US is expected to grow to 60% from today's share of 40% (Electricity Advisory Committee, 2008). This trend will require the electric power grid to be at its highest standards of reliability.

2.2.3 Dependence on fossil fuels

U.S. has the world's largest reserves of coal and hence historically, coal has been the dominant energy source for electricity generation. Figure 5 shows the share of coal in energy generation from 1950 to the present day. Even though the share of nuclear power and natural gas has increased over the years, about 60 percent of the electricity today is being produced from coal. Recent concerns about a global climatic crisis have put dependence on coal under heavy scrutiny.

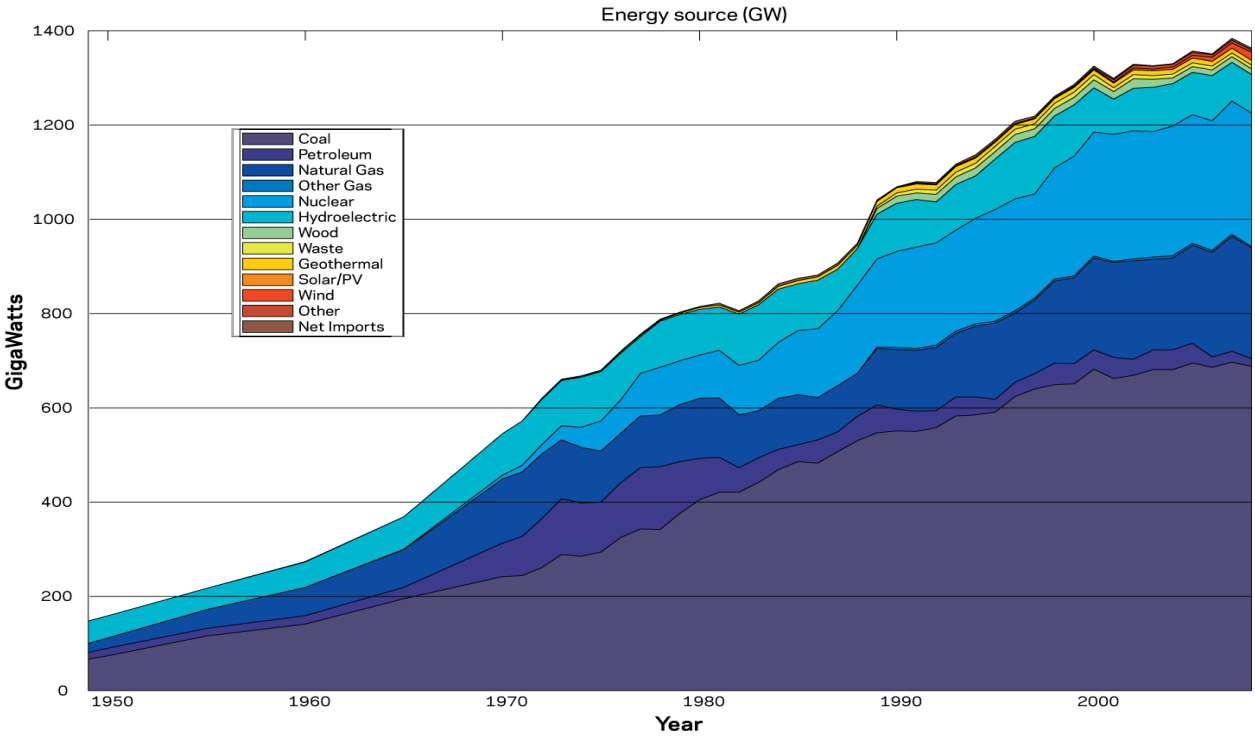

Figure 5- Graph showing the contribution of different energy sources to total electricity production from 1950 to 2010 (in GW) **(ENERGYliteracy.com, 2011)**

Reliance on coal to meet the increasing electricity demands will put great strain on the already deteriorating environment. As the energy density of coal is low (24 megajoules per kilogram, MJ/kg) compared to natural gas (46.4 MJ/kg) or Uranium 238 (20,000,000 MJ/kg), more fuel needs to be burnt per unit of energy produced. But coal also produces a greater amount of carbon dioxide compared to natural gas or petroleum. As a result, excess usage of coal will tremendously increase carbon dioxide emissions. Studies also suggest that the energy content of coal is decreasing gradually. The decline in quality of coal is estimated to be about 30% since 1955 (Heinberg, 2008).

Increasing elecricity cost has been a big concern in the last decade. Figure 6 shows the average retail price of electricity from 1973 to 2006. In August 2011, the average retail price of electricity was

12.17 cents per kilowatthour (¢/kwh) for the residential sector, 10.83 ¢/kwh for the commercial sector and 7.47 ¢/kwh for the industrial sector (Energy Information Administration, Electric Power Monthly-August 2011, 2011). Price of electricity is tightly tied with the price of oil and coal. Figure 7 and 8 show the price of coal and oil respectively, since 2001. Comparing the trend presented by price of coal and oil in Figure 7 and 8 with the trend presented by electricity retail prices in Figure 6, a direct relationship between the prices can be concluded. An increase in the price of oil and coal will most definitely cause an increase in the price of electricity.

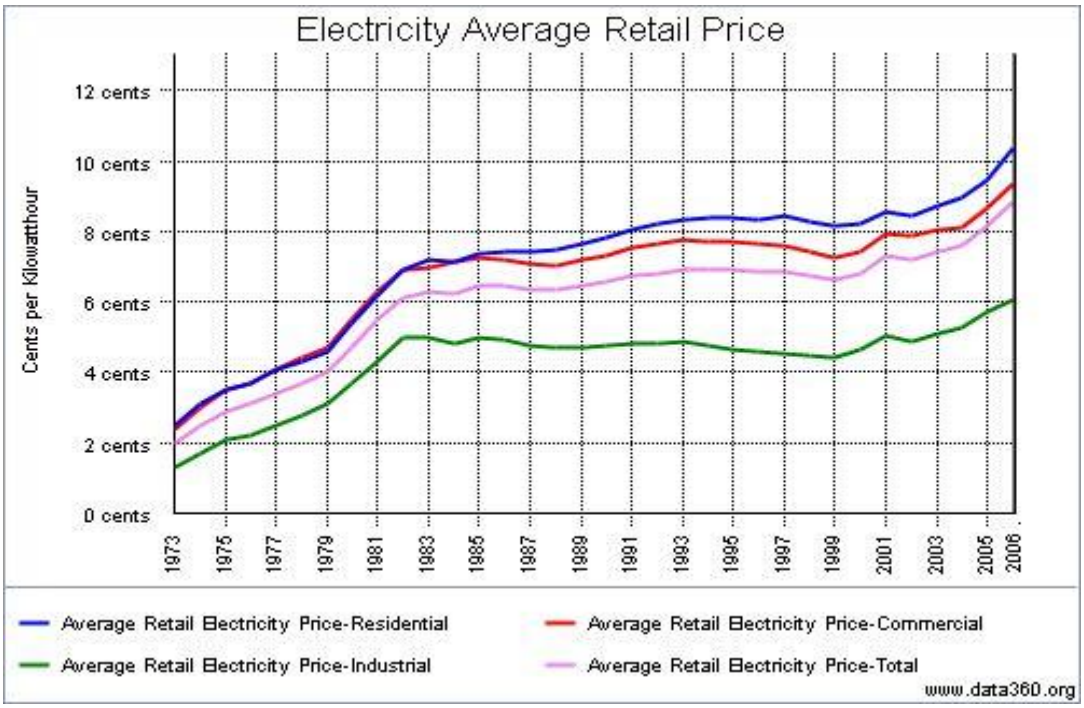

Figure 6- Price chart showing the average retail price of electricity by sector from 1973-2006

Figure 7- Graph showing trend in the price of coal in the past decade **(indexmundi, 2011)**

Figure 8- Graph showing trend in the price of crude oil in the past decade **(indexmundi, 2011)**

2.2.4 Sustainability

Sustainable energy can be defined as "a dynamic harmony between the equitable availability of the energy-intensive goods and services to all people and the preservation of the earth for future generations" (Tester, 2005). The U.S. accounts for only four percent of the world's population yet contributes towards 25% of the total emission of greenhouse gases. Due to its heavy reliance on fossil fuels, the electric power industry is responsible for 33% of the total emissions in the U.S. (Center for Climate and Energy Solutions, 2009). Research suggests that greenhouse gasses are detrimental to the environment and are causing climatic changes of global scale.

Over the past decade, there has been increasing interest shown towards electricity generation from renewable energy sources like solar, wind and geothermal. Renewable energy sources offer a sustainable alternative to coal and other fossil fuels. That is, renewable sources cause no net harm to the environment and their supply is inexhaustible. But the problem lies in integrating these sources with the electric power grid. As mentioned before, the electric power grid is a just-in-time delivery system which requires energy generation to be predictable and repeatable. Renewable energy sources are sporadic in nature and their integration with the existing grid is challenging.

Also, generation of electricity from renewable sources is capital and space intensive. As shown in Figure 9, two of the major renewable energy sources, wind and solar are associated with higher construction costs as compared to coal or natural gas (Morgan, 2010). The average cost of construction for a solar power plant is around $6,500-7,500 per kilowatt of electricity (National Resources Defense Council) whereas that for a coal powered plant is around $1,000-1,500 per kilowatt (International

Energy Agency, 2010). Though initial investment is high for electricity generation from renewable energy, production and operating costs are much lower than traditional generation. Benefits are usually tangible after a breakeven period ranging between 10-20 years.

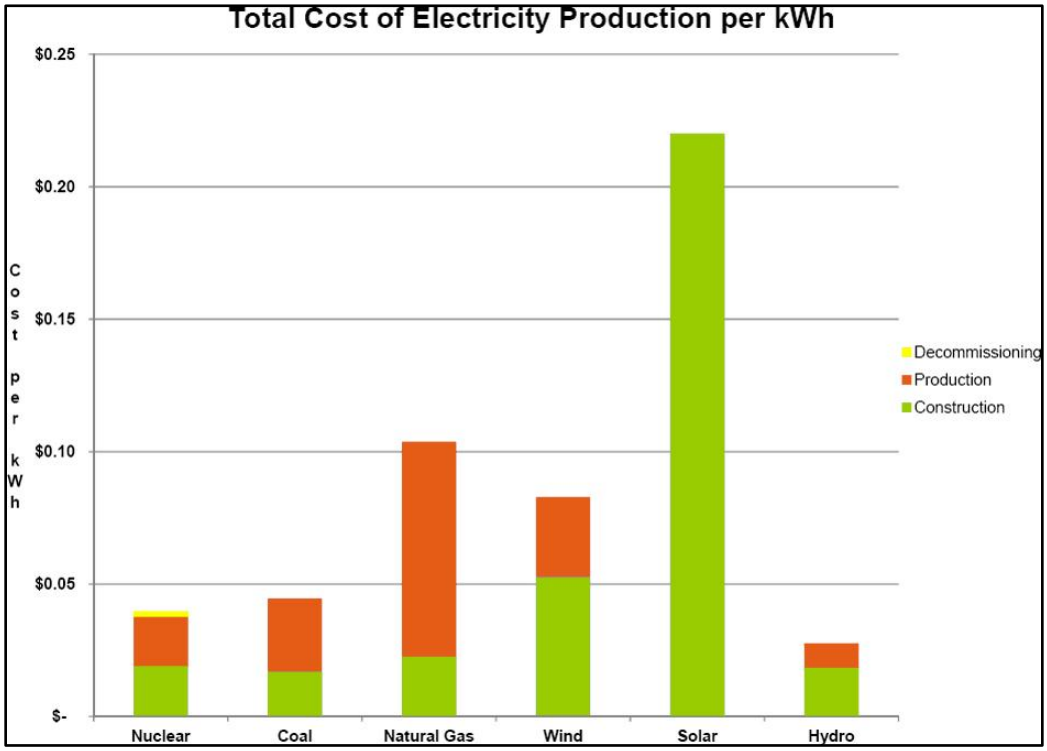

Figure 9- Total cost of electricity production per kWh in 2008 **(Nuclear Fissionary, 2008)**

Space considerations are also important, especially for solar power. Consider a Kyocera KC200GT 200 Watt solar cell. Each cell occupies an area of about 15 sq. ft. To produce one megawatt of electricity (the capacity of a 'small' coal powered plant) at its rated 16% efficiency, 31,250 cells would be needed which amounts to a total panel area of 468,750 sq. ft. or 10.76 acres[1]. The sheer amount of space required to produce appreciable electric power burdens investment, especially in cities. But irrespective of short-comings, a shift towards renewable energy is vital in order to reduce the nation's carbon footprint and move towards global environmental leadership (Pepermans, Driesen, Haeseldonckx, Belmans, & D'haeseleer, 2005).

2.2.5 Consumer engagement

Historically, electric utility companies have been monopolies regulated by state and federal agencies. Customers have had no choice with regards to the electricity they buy. They subscribe to a

[1] Data retrieved from http://www.affordable-solar.com/kyocera.kc200gt.200watt.solar.panel.htm on 02/15/2011

utility company and pay for usage at the prescribed cost. Along with paying for the actual usage of electricity, customers also pay for the supporting infrastructure in form of transmission and distribution charges. With rising electricity costs and environmental concerns, consumers are now willing for more engagement in the electric power grid. Environmentally conscious customers are concerned with where their electricity comes from. But the grid as it stands today, offers minimum communication between consumers and suppliers, making consumer engagement difficult (Electricity Advisory Committee, 2008).

2.3 U.S. Electric Power Grid- The Way Ahead

The current state of the U.S. electric power grid is a cause for deep concern among experts. The American Society of Civil Engineers, in its 2009 Report Card for America's Infrastructure gives the U.S. Electric Power Grid a rating of 'D+' ('D+' corresponding to poor with 'A' being exceptional). The report concludes the following:

"The "information economy" requires a reliable, secure, and affordable electric system to grow and prosper. Unless substantial amounts of capital are invested over the next several decades in new generation, transmission, and distribution facilities, service quality will degrade and costs will go up. These investments will involve new technologies that improve the existing electric system and possibly advanced technologies that could revolutionize the electric grid." (American Society of Civil Engineers, 2009, p. 138)

To make matters worse, the demand for electricity continues to grow at an alarming rate. By 2035, the electricity consumption of the U.S. is expected to increase by 14% which requires installation of about 56 GW of generation capacity (Energy Information Administration, Annual Energy Outlook, 2010).To meet the increasing demand for electricity while addressing current problems of the grid presents a daunting task.

The Department of Energy (DOE) and its numerous collaborators have been actively working on solutions to problems faced by the grid. The problems require multi-faceted solutions spanning policy changes both at the federal and state levels; research, development and deployment of new technologies; and increased investment in the grid. This section describes a few of these solutions, some already implemented and others still in development.

2.3.1 Energy Independence and Security Act of 2007

The Energy Independence and Security Act of 2007 (EISA) marks the beginning of a new era of modernization of the U.S. electric power grid. EISA introduced the concept of the "Smart Grid" to tackle problems of reliability, security and sustainability posed by the current grid. It also contains provisions to increase energy efficiency in the U.S. and promote production of renewable fuels (Sissine, 2007).

EISA was enacted by George W. Bush on December 19, 2007 in response to the *Twenty in Ten* challenge presented in his State of the Union address. "*Twenty in Ten*" represented the goal of reducing U.S. gasoline consumption by 20% in the next ten years (Bush, 2007). The key provisions enacted into law by EISA, relevant to this project are as follows (110th Congress, 2007) (Sissine, 2007):

- The law aims at improving efficiency and cost effectiveness of different renewable energy technologies by promoting extensive research and development in the field
- EISA mandates the Department of Energy (DOE) to perform an assessment of Concentrated Solar Power (CSP) technologies and their integration into the grid at utility-scale (SEC. 603)
- DOE is instructed to promote research, development, demonstration and commercialization of geothermal energy (SEC. 613) and set up a grant program to demonstrate geothermal potential from oil and gas fields (SEC. 616)
- DOE is also instructed to set up research and development centers for technology focusing on electricity production from waves, tides, currents and ocean thermal differences (SEC. 633)
- The law authorizes funding of $10 billion over 10 years towards research and development of energy storage technologies (SEC. 641) and mandates the DOE to set up four energy storage research centers to pioneer storage systems for transportation and the electric power grid
- The law provides provisions for renewable energy construction grants for local governments, utilities and Indian tribes, and authorizes grants that match up to 50% of the total cost for generating capacities under 15 MW (SEC. 803)
- EISA authorizes the Small Business Administration (SBA) to grant loans to small businesses to develop and invest in renewable energy projects (Title XII)
- EISA initiates modernization of the electric power grid through introduction of the 'Smart Grid' and instructs the DOE to report to Congress on the deployment of Smart Grid technologies and any barriers to deployment. The DOE is directed to conduct Smart Grid research and development to determine penetrability and effectiveness of associated technologies. The

National Institute of Standards and Technology (NIST) is enlisted to establish protocols and standards to ensure integration of various Smart Grid components. (Title XIII)

The original bill also included a national requirement on Renewable Portfolio Standards mandating 15% of total electricity produced by utilities to come from renewable sources by 2020. However, this provision was debated and dropped from the bill. Provisions to remove about $22 billion of oil and gas subsidies to incentivize renewable fuel production were also rejected (Sissine, 2007).

2.3.2 The Smart Grid

The 'Smart Grid' project was initiated by the Department of Energy (DOE) in accordance with the Energy Independence and Security Act of 2007. The primary goal of the Smart Grid is to modernize the existing electric power grid and address concerns related to reliability, security, efficiency and sustainability. The term 'Smart Grid' refers to a distribution system that allows for flow of information from a customer's meter in two directions; both inside the house to thermostats, appliances, and other devices, and from the house back to the utilities (Sissine, 2007, p. 20). Following are some of the important features of the Smart Grid:

Two-way Communication and Monitoring

Two-way communication is the flagship feature of the Smart Grid. The Smart Grid utilizes advanced low-cost digital communication technologies to share information between utilities, consumers and regulatory agencies. This open gateway of communication enables increase in efficiency and reliability of the electric power grid (Electricity Advisory Committee, 2008).

Advanced Metering Infrastructure (AMI) is an important component of the Smart Grid. AMI involves development of a real-time pricing system and providing customers the ability to monitor their usage. With the help of 'smart' electronic devices, customers will be able to set preferences that automatically control electricity usage in response to time-dependent price signals. This will result in reduction of consumption during peak periods when the price of electricity is high (Electricity Advisory Committee, 2008). Utilities also benefit from AMI, by being able to receive data on their customer's consumption behavior. Such data will help utilities develop a demand-response framework and enable them to accurately predict demand, resulting in efficient allocation of electricity generating resources (Electricity Advisory Committee, 2008).

Two-way communication also assists utilities in maintaining a reliable supply of electricity. Even today in many areas of the U.S., the only way for utility companies to know of a power outage is when a customer calls to report one. There are no systems in place to continuously monitor health of the electric power grid in real-time (Lammers, 2011). Digital data acquisition enabled by the Smart Grid will provide utilities new ways to proactively monitor the grid and take precautionary measures to prevent outages (Electricity Advisory Committee, 2008). After all, prevention is better than cure.

Distributed Generation

Distributed generation has received much coverage in the recent past owing to the opportunities it presents in increasing the security, reliability and sustainability of the electric power grid (Pepermans, Driesen, Haeseldonckx, Belmans, & D'haeseleer, 2005).Distributed generation is defined as the "*the use of small-scale power generation technologies located close to the load being served, capable of lowering costs, improving reliability, reducing emissions and expanding energy options*" (Electricity Advisory Committee, 2008, p. 12).

A distributed generation system has the flexibility to accommodate various types of generation technologies and energy sources into the power grid. With the digital communication capabilities enabled by the Smart Grid, integration of small scale power generating units into the grid becomes easier. Renewable energy sources being distributed in nature can be effectively exploited and utilized for power generation in the Smart Grid. Greater use of renewable energy sources promotes sustainability of the grid and reduces the environmental footprint of the electric power industry (Alanne & Saari, 2004).

Distributed generation also offers increase in efficiency by moving generating units close to consumption points, thereby eliminating transmission losses (Alanne & Saari, 2004). It gives consumers an opportunity to engage in small-scale electricity generation to save costs. More importantly in the context of this project, distributed generation allows for the utilization of previously abandoned brownfield sites for small-scale electricity generation.

Current Efforts in the Smart Grid Project

The Department of Energy has initiated many projects aimed towards realization of the Smart Grid. The projects deal with research, development and demonstration of Smart Grid technologies. Some of the notable projects are as follows:

- *Distribution Management System (DMS)* platform being developed by the University of Hawaii

DMS is an energy management platform offering advanced functions for home energy management. The platform incorporates the Advanced Metering Infrastructure (AMI) and integrates consumer demand-response with optimal dispatch of electricity and load management by grid operators (Electricity Advisory Committee, 2008).

- *High Penetration of Clean Energy Technologies* by the City of Fort Collins

  The project is exploring integration of solar, wind and other distributed energy resources into the electric power grid. Currently, an aggregate capacity of 3.5 MW from 30 different types of distributed generation systems is installed across 5 locations in Fort Collins, Colorado. A demand-response system is being developed to reliably distribute electricity utilizing all the different generating systems. The project will determine the degree of penetration for distributed resources (Electricity Advisory Committee, 2008).

2.3.3 Renewable Portfolio Standards

To incentivize utility companies to switch to renewable energy sources, some states have introduced Renewable Portfolio Standards (RPS) or Alternative Energy Portfolio Standards (AEPS). RPS is a state policy mandating utilities to produce or purchase a certain portion of their generating capacity from renewable energy sources (DOE-EERE, States with Renewable Portfolio Standards, 2009). As of November 2011, 30 states have adopted mandated RPS or AEPS and eight states have set non-binding, voluntary goals (DSIRE, RPS Data Spreadsheet, 2011). Together, these states account for more than half of the total electricity sales in the U.S. (DOE-EERE, 2009)

RPS mandates for each state are decided independently by the state authorities and mandates vary by state. Some states have set humble goals (Pennsylvania- 8% by 2020) while others have more ambitious goals (California- 33% by 2030) (DOE-EERE, States with Renewable Portfolio Standards, 2009). Some states also have requirements for specific types of renewable energy sources. For example, presently Massachusetts requires five percent and an additional increase of one percent each year from RPS Class I, consisting of solar photovoltaic, solar thermal electric, wind, hydropower, landfill methane, hydrokinetic, geothermal and biomass fuel. RPS Class II mandates that a minimum percentage of electricity sales should come from two sources- renewable energy and waste energy. The current mandate is 3.5 percent from renewable energy and 3.5 percent from waste energy (Commonwealth of Massachusetts, RPS and APS Program Summaries, 2011).

The general consensus among experts is that RPS mandates have resulted in increased share of renewable sources in the energy mix of participating states (Carley, 2009) . Texas for example, deployed

915 megawatts of wind generators in 2001, almost double the year's RPS requirement. In Massachusetts electricity from renewable generating units exceeded the RPS requirements in 2007 and 2008 (Executive Office of Energy and Environmental Affairs, 2010). RPS policies have been one of the strongest mechanisms adopted in the U.S. to encourage renewable energy sources (Carley, 2009).

2.3.4 Net Metering

While RPS promotes utilities to invest in renewable energy generation, net metering incentivizes individual consumers to invest in on-site renewable energy generation. Net metering allows consumers to use electricity generated on-site to offset their consumption of utility-provided electric power over a billing period. This is achieved by meters that can run backward when consumers generate electricity in excess of their demand. The meter ensures that the consumer receives retail prices for the excess electricity generated (DOE-EERE, Green Power Markets, 2011).

Net metering policy was enacted under the Energy Policy Act of 2005. According to the policy, electric utilities are required to provide net metering services to customers upon request (109th Congress, 2005). In 2010, net metering was offered in 43 states, Washington D.C. and Puerto Rico. Different states have different caps on maximum net metering capacity. For example, California has set its net metering limit at 1 MW for privately owned generation systems and 5 MW for systems owned by a local government or a university (DSIRE, California - Net Metering , 2011),while Connecticut has its net metering limit set at 2 MW for all entities (DSIRE, 2011).

Net metering in Massachusetts

Net metering has been available in the state of Massachusetts since 1980s. In 2008, Governor Patrick signed the Green Communities Act into law, increasing the net metering capacity limit from 60 kW to 2 MW (Commonwealth of Massachusetts, 2011). Massachusetts allows for the following provisions in its net metering policy:

- A party does not need to own the generating facility they install to receive net metering credits. Third party financing and ownership is permitted.
- A group of people can collectively own a generating facility and individually receive net metering credits for the electricity generated by the facility
- 'Neighborhood net metering' is offered to a group of 10 or more residential or non-residential customers

- The party receiving net metering credits and the installed generation facility can be geographically separate as long as they are in the same service territory and the ISO-New England load zone
- *In February 2011, the Massachusetts Department of Public Utilities opened up a docket to examine net metering and interconnection of distributed generation. If this examination results in a policy change, the party receiving net metering credits and the generating facility will no longer need to be in the same ISO-NE load zone* (Massachusetts Department of Public Utilities, 2011).

2.3.5 Federal and State Incentives for Renewable Energy Projects

Along with implementing new policies, federal and state authorities have introduced numerous incentive programs to offset the initial investment for deployment of power generation using renewable energy sources. Currently, there are 17 federal programs and 1047 state programs incentivizing development of renewable energy (DSIRE, 2011). Programs span a variety of incentives like personal and corporate tax benefits, rebates, grants, loans, bonds, performance based benefits, etc. In 2009, the U.S. invested $18.6 billion in renewable energy projects (Shannon, 2010).

The state of Massachusetts offers five tax benefit programs, four rebate programs, five grant programs, two loan programs and one performance based incentive program to encourage renewable energy sources. Utilities like National Grid and NSTAR also offer rebate programs to customers for energy efficiency. In addition, electricity generated from solar power can qualify as Solar Renewable Energy Credits (SRECs) and can be bought by utilities at a minimum price of $300/MWh to fulfill the state RPS requirements (DSIRE, 2011). Detailed information on individual programs can be obtained from the Database of State Incentives for Renewables and Efficiency (DSIRE) website.

3. Brownfields and RE-Powering America's Land

Redevelopment of abandoned industrial and commercial sites i.e. *brownfields*, has been a topic of interest since the 1990s when urban sprawl and unavailability of developable land started becoming a problem (Community Reinvestment Forum, 2003). Since then many legislative changes and incentive programs have been introduced at both the federal and state levels to promote revitalization of brownfield sites. RE-Powering America's Land is one such program started by the U.S. Environmental Protection Agency (EPA) in 2008 to promote development of renewable energy on brownfield sites. This chapter is dedicated to discussion of the RE-Powering America's Land initiative. Before discussing the initiative, a definition of the term brownfield is provided followed by a brief on benefits and challenges of brownfield redevelopments and legislature related to brownfields.

3.1 Definition of a *Brownfield*

The term *brownfield* came into existence in June, 1992 at a U.S. Congressional hearing hosted by the Northeast Midwest Congressional Coalition (Wikipedia, 2011). Until 2002, an exact definition of the term was not established and different entities used different definitions. In 2002, the Small Business Liability Relief and Brownfields Revitalization Act of 2002 defined the term 'brownfield site' as- *real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant* (107th Congress, 2002, p. 115).

Though the term brownfield is associated with contamination, the level of contamination for a site to be called a brownfield is not specified in the Small Business Liability Relief and Brownfields Revitalization Act of 2002. Generally, the term brownfield refers to sites with a level of contamination that does not pose serious and immediate health and environmental threats, like abandoned gas stations, factories or former dry cleaning facilities. Brownfields mostly pose an economic or social threat as they prevent development in the surrounding area, hindering the local economy and quality of life for people. Sites that are heavily contaminated and pose a greater threat to human health and the environment are referred to as *superfund* sites (Community Reinvestment Forum, 2003). While differing in the levels of contamination, brownfield sites and superfund sites each have a separate set of legislature governing issues related to liability and policy enforcement. Brownfield sites are often confused with superfund sites and that is one of the reasons for hesitation show by investors to finance brownfield redevelopment programs (Abrams, 1997).

3.2 Benefits and Challenges of Brownfield Redevelopment

Redevelopment of brownfield properties offers many benefits to both the investor and the community, but it also faces some challenges. For the investor, brownfield properties offer access to inexpensive real estate in prime locations. Many brownfields were once part of the industrial section of a city and therefore are well connected to roads, electricity, heating and other amenities making commercial activities in these locations viable and convenient (Environmental Law Institute, 2011). A study conducted by the EPA in five pilot locations suggests that redeveloped brownfield sites offer greater location accessibility as compared to new development projects on vacant properties, and reduce average miles travelled by 37 to 52 percent (U.S. Environmental Protection Agency, 2011). Brownfield sites also help investors incur savings on construction costs by integrating existing infrastructure like walls, roofs, plumbing and load bearing columns into the new construction (Rhode Island Department of Environmental Management, 2003).

One of the main incentives for investors to develop brownfield properties is the tax benefits provided by the federal and state governments. The Brownfield Tax Incentive is a part of the Tax Relief Act of 1997 and it encourages cleanup and reuse of brownfields. The law allows cleanup costs at eligible properties to be written off as a deduction in the year incurred. In 2006, the law was amended to expand eligible types of cleanup projects (U.S. Environmental Protection Agency, 2011). Also, as many brownfields are located in Enterprise Zones, any companies operating in redeveloped facilities in these zones are eligible for significant tax savings, potentially up to $15,000 per employee (Rhode Island Department of Environmental Management, 2003).

Redevelopment of brownfields also offers many benefits to the community. Brownfields cause a hindrance to the growth real estate values by being unusable, visually revolting properties. Over a period of time, they result in depreciation of property values in the immediate vicinity. By redeveloping brownfields, the depreciation in property values can be stopped and further improved. A study by the U.S. EPA concluded that residential property values increased by two to three percent once a nearby brownfield has been cleaned up and redeveloped (U.S. Environmental Protection Agency, 2011). Redevelopment of brownfields can create new jobs. The U.S. EPA reports that 73,423 jobs were created in 2011 through its Brownfields Program (U.S. Environmental Protection Agency, 2011). Redeveloping brownfields also increases the quality of local environment by eliminating contaminants and reusing the land. The reusing of previously abandoned properties helps lift developmental pressures off vacant undeveloped areas or greenfields, thereby checking urban sprawl (Environmental Law Institute, 2011).

Along with the benefits that promote redevelopment of brownfields, there are also some challenges that hinder the development. Banks and private investors are often hesitant in handing out loans for brownfield projects due to issues of liability. Prospective developers are generally wary of liability charges for contaminants present in the brownfield site, under the Comprehensive Environmental Response, Compensation, Liability act of 1980 (CERCLA) also known as the "Superfund" (Community Reinvestment Forum, 2003). Brownfield redevelopment is also an expensive and difficult undertaking. If the site assessment and risk management are not done appropriately, a redevelopment project can run into problems and result in heavy losses (Canadian Institute for Environmental Law and Policy, 2011).

It is estimated that there are more than 450,000 brownfield sites in the U.S. accounting for billions of acres of unusable land (U.S. Environmetal Protection Agency, 2011). If utilized effectively, brownfields can play an important role in sustainable urban planning and development. To effectively utilize brownfields, appropriate policies and programs need to be implemented at both federal and state levels addressing issues of liability and cost effectiveness. The next section briefly describes some of the existing legislature related to brownfields.

3.3 Brownfield Legislature

3.3.1 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA, commonly known as Superfund was one of the first brownfields related laws to be passed in the U.S. It was enacted on December 11, 1980 to create a federal authority over releases of hazardous contaminants that endangered public health or environment. CERCLA gave EPA the authority to seek out parties responsible for any release of contaminants and assure their cooperation in the cleanup. This law also created a contamination tax on chemical and petroleum industries and over the first five years $1.6 billion were collected in taxes. The amount went towards a trust fund for cleaning up abandoned waste sites, when no responsible party could be established (U.S. Environmental Protection Agency, 2011).

The EPA uses various enforcement tools like orders, consent decrees and other settlements to ensure private party cleanup. If the parties responsible fail to act, the EPA administers cleanup of the site and recovers costs from the viable entities. EPA also cleans up abandoned sites when potentially responsible parties cannot be identified. EPA is authorized to enforce CERCLA in all 50 states and U.S. territories (U.S. Environmental Protection Agency, 2011).

The Superfund Amendments and Reauthorization Act (SARA) of 1986 amended and reauthorized the CERCLA. SARA reflected EPA's experience in administering the complex Superfund program during its first six years and made several important changes and additions to the program. SARA stressed the importance of permanent remedies and innovative treatment technologies in cleaning up hazardous waste sites. It encouraged greater citizen participation in deciding the nature and extent of cleanups. SARA also increased the size of the CERCLA trust fund to $8.5 billion (U.S. Environmental Protection Agency, 2011).

CERCLA has been a tool for aggressively administering liability charges related to contaminated lands since 1980 and the fear of being charged is one of the reasons why investors are hesitant to invest in brownfield properties (Abrams, 1997). So, in order to encourage investment in brownfield properties, Congress enacted the Small Business Liability Relief and Brownfields Revitalization Act in 2002. The Act provides immunity against Superfund liability to owners and prospective purchasers interested in redeveloping brownfield sites under certain conditions.

3.3.2 Small Business Liability Relief and Brownfields Revitalization Act

The Small Business Liability Relief and Brownfields Revitalization (SBLRBR) Act was enacted on January 11, 2002 to encourage private investment in brownfield properties. The law contained three titles dealing with funding and liability issues related to assessing and cleaning of contaminated properties. Title I expanded EPA's brownfields program by authorizing funding for assessment and cleanup of brownfields properties. Title II exempted neighboring property owners, prospective purchasers and innocent landowners from Superfund liability. Title III limited EPA's Superfund enforcement authority at sites cleaned up under a State response program and provided increased funding for state response programs (107th Congress, 2002).

Most notably, title II of the Act was a positive step towards encouraging brownfield redevelopment as it provided immunity to some entities against Superfund liability and hence giving them an opportunity to engage in brownfield projects. Section 102 of the Act exempts entities from Superfund liability if they can demonstrate that the total amount of contaminants contributed by them is less than 110 gallons of liquid materials or 200 pounds of solid materials and all or part of disposal or transport of contaminants occurred before April 1, 2001. Section 222 of the Act exempts prospective buyers and their tenants from liability as long as the person does not contribute to further

contamination of the property and does not impede the performance of any recovery action by the EPA or State environmental agencies (U.S. Environmental Protection Agency, 2011).

Along with exempting small businesses and prospective purchasers from Superfund liability, the Small Business Liability Relief and Brownfields Revitalization Act of 2002 further catalyzed redevelopment of brownfield sites by authorizing numerous funding programs. The Act authorizes $200 million per year for brownfield assessment and cleanup. Grants up to $200,000 is authorized per site to create inventory, assess and plan brownfield cleanup. The Act also authorizes grants of up to $1 million to eligible entities to setup revolving loan funds for cleaning up of brownfields. Eligible entities can be States, Tribes, local governments, land clearance authorities, regional councils, redevelopment agencies or other quasi-governmental entities created by States or local governments (107th Congress, 2002).

3.3.3 Community Reinvestment Act (CRA)

The Community Reinvestment Act (CRA) was enacted in 1977 to stabilize declining condition of the nation's low to moderate income urban neighborhoods. CRA requires banks, thrifts, and other lenders to make capital available in low- and moderate-income urban neighborhoods for community development projects (U.S. Environmental Protection Agency, 2011). Redevelopment of brownfield sites qualifies as a community development project and the lending agencies can receive CRA credit for investing in these redevelopment projects. A lender's CRA record is taken into account when considering the institution's application for deposit facilities, including mergers and acquisitions (FFIEC, 2009). In this manner, CRA acts as a great impetus for lending agencies like banks to make capital available for brownfields redevelopment projects (Community Reinvestment Forum, 2003).

3.4 EPA's Involvement in Brownfield Redevelopment

3.4.1 The Brownfields Program

The U.S. Environmental Protection Agency (EPA) has been instrumental in developing proven, results-oriented brownfields relief policies since 1995. In 1995, EPA introduced the Brownfields Program to catalyze development and reuse of brownfield properties. The Brownfields Program was aimed at providing a framework to states, communities and stakeholders, for timely action in assessing, cleaning and sustainably reusing brownfields. In 2002, policies of the Brownfields Program were passed into law by the Small Business Liability Relief and Brownfields Revitalization Act (U.S. Environmetal Protection Agency, 2011). Introduction of this Act led to greater penetration of the EPA's Brownfields Program. As

of December 2011, the Brownfields Program has resulted in the assessment of 17,979 sites among which 692 sites, accounting for 25,493 acres have been successfully cleaned up. Assessment and cleanup activities under EPA's funding have leveraged $17.7 billion and 73,423 jobs nationwide (U.S. Environmental Protection Agency, 2011).

Along with providing a policy framework for brownfields related activities, the Brownfields Program also provides extensive grants and funding opportunities for brownfield assessment, cleanup, workforce training and technical assistance. Following are the different types of grants and funding available through the EPA's Brownfields Program (U.S. Environmental Protection Agency, 2011):

- Area-Wide Planning Pilot Program

  Through the Area-Wide Planning Pilot Program, EPA provides financial assistance to communities interested in developing an area-wide plan for redeveloping a brownfield site and the surrounding area. Revitalizing the area surrounding a brownfield site is vital to the success of brownfield reuse. In 2011, 23 communities were selected for the pilot program and each community was granted up to $175,000 for developing an area-wide revitalization plan (U.S. Environmental Protection Agency, 2011).

- Assessment Grants

  State, local, and tribal governments; land clearance authorities and other quasi-governmental entities; regional councils or redevelopment agencies can apply for assessments grants to inventory, characterize, assess and conduct planning in contaminated brownfield sites. Grants up to $200,000 are awarded to individual entities for brownfield site assessment. In well warranted cases, an entity can apply for grants up to $350,000. A coalition of three or more eligible applicants can also apply for coalition grants up to $1 million. Assessment activities need to be performed within three years (Office of Solid Waste and Emergency Response, 2009, p. 1).

- Revolving Loan Fund Grants

  EPA provides grants to state, local and tribal governments to set up low interest loans that can be used to perform cleanup activities at brownfield sites. Grant recipients can disburse the loan through sub-grants at low interest rates and capitalize the revolving loan fund. After repayment of a loan, the amount can be lent again thus creating a steady source of capital in the community for brownfield cleanup (Office of Solid Waste and Emergency Response, 2009, p. 1).

- Cleanup Grants

  Grants up to $200,000 per site are available to eligible entities to perform cleanup of hazardous contaminants on brownfield sites. To be eligible for cleanup grants, the entity needs to have ownership of the site to be cleaned. These grants require a 20 percent cost share which can be contribution of money, labor, materials or services.

- Environmental Workforce Development and Job Training Grants

  Environmental Workforce Development and Job Training Grants provide funding to recruit mainly low income, minority, and unemployed residents of brownfield areas and train them in skills required to obtain sustainable employment in the environmental field focusing on assessment and cleanup of brownfields (Office of Brownfields and Land Revitalization, 2011).

- Training, Research, and Technical Assistance Grants

  The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) authorizes EPA to provide eligible entities and non-profit organizations funds for training, research and technical assistance related to brownfield revitalization. A number of factors are taken into consideration while disbursing such grants to an entity. These factors include community need, ability to manage funds, impact on human health and environment, and ability to use existing infrastructure (Office of Brownfields and Land Revitalization, 2011).

- Targeted Brownfields Assessment

  The Targeted Brownfields Assessment (TBA) program as authorized under the Small Business Liability Relief and Brownfields Revitalization Act of 2002 provides funding, especially to those entities without EPA's Brownfields Assessment Grants. The grants are available directly through EPA and also through EPA's Regional Brownfields Offices (Office of Solid Waste and Emergency Response, 2007, p. 1).

3.4.2 RE-Powering America's Land Initiative

As part of EPA's continued efforts in formulating effective brownfield redevelopment programs, the RE-*Powering America's Land: Siting Renewable Energy on Potentially Contaminated Land and Mine Sites* initiative was introduced in September 2008. The initiative seeks to encourage siting renewable energy generation facilities on potentially contaminated land like brownfields, superfund sites, former gas stations and mine sites. The program provides technical and financial assistance to tribes, local, regional, and state governments and non-profit organizations who are interested in developing

renewable energy on contaminated lands. In collaboration with the National Renewable Energy Laboratory (NREL), EPA has identified 11,000 contaminated sites accounting for 15 million acres of land across the U.S., for development of renewable energy (U.S. Environmental Protection Agency, 2011). NREL's expertise has been enlisted to assess the best renewable energy technology for a site, potential electricity generating capacity of the technology used and economic feasibility of the project (Matthews, US EPA RE-Powering Feasibility Studies, 2011).

RE-Powering America's Land is a positive step towards solving two of the nation's prominent problems- energy security and sustainability, and urban sprawl (Matthews, US EPA RE-Powering Feasibility Studies, 2011). Using contaminated wasteland for developing renewable energy decreases the amount of green space used for siting energy generation facilities while increasing the amount of renewable energy generated in the nation. The RE-Powering America's Land initiative also presents new opportunities to help empower low income and minority communities that typically surround the brownfield sites. Section 3.5 explores the RE-Powering America's Land initiative and assesses some of the success stories published by the EPA.

3.5 RE-Powering America's Land Initiative

RE-Powering America's Land initiative by itself is not a financial incentive program, but it offers technical assistance related to the unique situations faced in siting renewable energy on contaminated sites. The initiative combines EPA's expertise in contaminated land revitalization with NREL's expertise in renewable energy development to provide useful resources to entities interested in developing renewable energy on former contaminated areas like brownfields, superfund sites, landfills and mine sites (Center for Program Analysis, 2009). As this project only deals with redevelopment of brownfields, only those aspects of RE-Powering America's Land initiative applicable to siting renewable energy on brownfield sites are discussed subsequently.

RE-Powering America's Land initiative, when applied to brownfield sites is a multi-pronged approach that layers two sets of programs and policies- EPA's Brownfields Program and federal, state, and regional renewable energy development programs. Financial support required for implementation of projects under the RE-Powering America's Land initiative is obtained from brownfield revitalization grants and loans mentioned in section 3.4.1, as well as from federal and state incentives for renewable energy generation mentioned in section 2.3.5. Technical assistance regarding feasibility of siting renewable energy on a particular brownfield site, the appropriate renewable energy technology for the

site, effective use of the technology and economic considerations is provided to project developers by NREL, while EPA advises on issues related to brownfield assessment, cleanup of contaminants and liability concerns .

3.5.1 Structure of RE-Powering America's Land Initiative

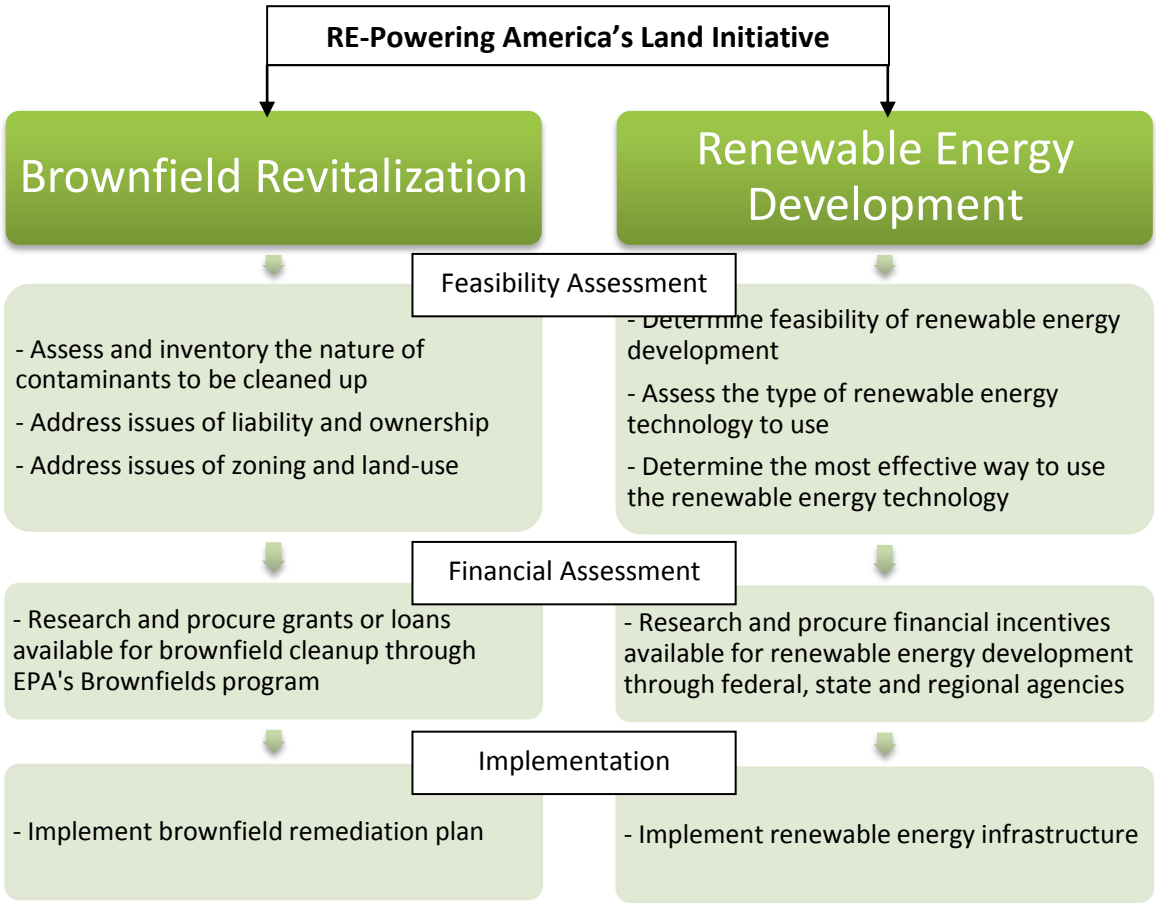

Figure 10- Chart showing the generic workflow of a RE-Powering America's Land project

The exact workflow and structure of each project under the RE-Powering America's Land initiative tends to be different, as the problems faced and corresponding solutions at each contaminated site and with each renewable energy technology are different. Figure 11 shows the generic flow of a typical RE-Powering America's Land project. As shown in the flowchart, every project under the RE-Powering America's Land initiative is in fact a combination of two parallel projects, one dealing with brownfield remediation and the other with renewable energy development. The purpose of RE-Powering America's Land initiative is to provide appropriate resources to project developers at every

stage of project assessment, planning and implementation (U.S. Environmental Protection Agency, 2009). The following sections describe the steps involved in a RE-Powering America's Land project.

3.5.1.1 Project Initiation

A renewable energy development project can be initiated on a brownfield site by any of the following entities with permission and support of the site owner (Matthews, 2011):

- State government
- Tribal government
- Local government
- Regional government
- Non-profit organization incorporated in the U.S.
- Academic institution that has demonstrated partnership with a governmental organization

An interested entity must file an application with the U.S. EPA to be considered for a RE-Powering America feasibility study on the brownfield site. Call for applications are announced on the RE-Powering America's Land website (http://www.epa.gov/oswercpa/studies.htm) every year. In 2011, the applications for RE-Powering America's Land feasibility studies were announced during early part of the year and were due in the month of May. 26 applicants were eventually selected for the feasibility studies, each of 12-24 months durations (Matthews, 2011). EPA prefers applications for utility or commercial scale renewable energy projects and prefers projects with opportunity to place power generation infrastructure directly on the land rather than on any existing buildings (Matthews, 2011, p. 1).

Before applying for a feasibility study, an interested entity can use the mapping tools available through the RE-Powering America's Land initiative to gain information regarding a site, its cleanup status and renewable energy resource information (U.S. Environmental Protection Agency, 2011). In collaboration with the NREL, EPA has tracked more than 11,000 sites that have potential for developing renewable energy sources and all these sites are incorporated into the Google Earth mapping tool by the RE-Powering America's Land initiative. Information about the Google Earth mapping tool is available on RE-Powering America's Land initiative website (http://www.epa.gov/oswercpa/mapping_tool.htm).

3.5.1.2 Feasibility Assessment

Feasibility assessment at a brownfield site determines whether renewable energy is the best reuse option for the site and which renewable energy technology best suits the site. Two types of

assessments are required in developing renewable energy on brownfield sites- assessment of the brownfield site and assessment of renewable energy options for the site, led by EPA and NREL respectively (EPA, NREL, 2011).

Brownfield Assessment- A brownfield site assessment is carried out with the guidance of EPA to identify and quantify the nature of contaminants present on the site, level of cleanup required for the proposed reuse of the site, remediation actions required to sustainably cleanup the contaminants and preventive steps to minimize future effects on human health and the environment. EPA also provides assistance in matters of liability and ownership, as determined by the Small Business Liability Relief and Brownfields Revitalization Act of 2002 (U.S. Environmental Protection Agency, 2009). Project developers can apply for funding through EPA's Brownfields Program for this assessment action. The funding programs applicable are- Area-Wide Planning Pilot Program, Assessment Grants and Targeted Brownfields Assessment. A description of these programs is provided in section 3.4.1.

Renewable Energy Assessment- An assessment of renewable energy resources with the help of NREL determines the following (Matthews, US EPA RE-Powering Feasibility Studies- 2011 Request for Applications (RFA), 2011, p. 1)

- The economic and physical viability of the site for exploiting renewable energy resources
- Quantitative analysis of the renewable resource availability at the site
- Appropriate power generation technology for the site
- Size, design and placement of the generating system
- Financial considerations like capital costs, payback period, incentives, etc.
- Impact on the community, like creation of jobs

The types of renewable energy sources considered by NREL for the RE-Powering America's Land initiative are Solar Photovoltaic (PV), Concentrated Solar Power (CSP), wind, bio-refinery (from wood or crop waste), bio-power (from wood or crop waste), and geothermal energy (Matthews, 2011, p. 1). Along with RE-Powering America's Land initiative's assistance, project developers can apply for various renewable energy assessment grants provided by different state and regional agencies.

3.5.1.3 Financial Considerations

Developing renewable energy resources by itself is an expensive undertaking. When combined with the cleanup costs associated with developing renewable energy on brownfields, the capital costs can be further daunting. But RE-Powering America's Land initiative offers a unique opportunity that

allows a project developer to benefit from two sets of incentive programs. A project developer can utilize the financial incentives provided by EPA under the Brownfields Program for cleanup purposes and utilize various incentives available for renewable energy development provided by federal, state, regional and private agencies. The RE-Powering America's Land initiative has an exhaustive list of incentives available for renewable energy development organized by state on its website (http://www.epa.gov/oswercpa/incentives.htm) (U.S. Environmental Protection Agency, 2009).

3.5.1.4 Post-Completion Usage

RE-Powering America's Land initiative does not specify any guidelines for usage of a remediated brownfield site after completion of a renewable energy development project. The initiative suggests that the energy produced at a site can be sold as Renewable Energy Certificates (RECs) to utilities in states with Renewable Portfolio Standards (RPS). Some of the successfully completed projects under the RE-Powering America's Land initiative also power nearby facilities like water treatment plants, waste treatment plants or commercial and residential buildings (U.S. Environmental Protection Agency, 2009).

3.5.1.5 Community Involvement

RE-Powering America's Land initiative promotes creation of jobs in the local community during the brownfield remediation and renewable energy development phases of a project. In 2010, RE-Powering America's Land initiative drafted a management plan to lay out the key areas of focus for the next two years. One of the key areas of focus mentioned in the plan pertains to development of a training module for workforce development training that will provide opportunities for environmental employment for residents in communities impacted by contaminated properties (Center for Program Analysis, 2010). EPA also provides funding for training and development of workforce in brownfield areas through its Brownfields Program. Though incentives and funding opportunities can encourage local job creation, RE-Powering America's Land initiative does not mandate any requirements on inclusion of local workforce or job creation.

3.5.2 Success Stories

Table 1 shows a list of projects successfully completed under the RE-Powering America's Land initiative, their intended end-usage and impacts (EPA, 2009). It can be observed that the end-usage of each project is different and it depends on various factors such as ownership of the site, generation capacity and community consensus.

Project Location	Renewable Energy Source	Size of the System	End-Usage of the System	Impact of the Project
Casper Winds, Wyoming	Wind	16.5 MW	Electricity sold to grid	Remediation and reuse of former contaminated land
Fort Carson, Colorado	Solar PV	2 MW	Electricity sold to grid	Provides 2.3% of Fort Carson's electricity needs at lowered cost. Expected to save Fort Carson $500,000 in electricity costs over 20 years
Lackawanna, New York	Wind	45 MW	Electricity sold to grid	The project will create 5 permanent jobs and 40 construction jobs
Nellis Air Force Base, Nevada	Solar PV	14 MW	Electricity sold to grid	Through a 20-year power purchase agreement, the project developer Nevada Power Company provides the Base power at a guaranteed fixed rate in return for solar RECs. The project is project to save the Nellis AFB $1 million over a course of 20 years
Richmond, California	Solar PV	1 MW	Electricity to power a resident storm water treatment facility	The project provides 30% of the electricity needs for the West County Wastewater District storm water treatment facility
Philadelphia Navy Yard, Philadelphia, PA	Solar PV	1.5 MW	Electricity sold to grid	The facility will create 10 permanent and 50 construction jobs

Table 1-Table showing the list of successful projects under the RE-Powering America's Land Initiative

4. Environmental Justice (EJ)

4.1 Introduction

The Environmental Justice is primarily a grassroots movement that burst into the national spotlight in 1987 when the United Church of Christ came up with a revolutionary report entitled *Toxic Wastes and Race in the United States* (Brodsky, 2007). The report noted that people of minority communities and people of race were far more likely to experience the adverse effects of hazardous waste disposal and contamination than people in predominantly white communities (United Church of Christ, 1987). The report found that race was a more significant factor than socio-economic status in relation with the location of commercial hazardous waste facilities. In 1987, three out of the five largest hazardous waste landfills in the country were found to be in Black or Hispanic communities (United Church of Christ, 1987). The study by the United Church of Christ concluded that the pattern displayed by location of hazardous waste facilities in predominantly minority communities and communities with people of color was not coincidental and intended. The report urged the President of the U.S. to mandate federal agencies to consider the impact of their policies and regulations on communities of color and ethnicity (United Church of Christ, 1987).

On October 27, 1991 the First National People of Color Environmental Leadership Summit was held in Washington D.C. The summit recognized racial implications on environmental injustice and it led to the adoption of 17 principles of Environmental Justice. The summit sought to build a national and international movement of all people of color to fight environmental racism (Bullard R. D., 2005). In 1992, the EPA administrator William Reilly established the Office of Environmental Equality under the Bush administration, which was renamed as the Office of Environmental Justice under the Clinton administration. The year 1994 marked a leap forward in the environmental justice movement when President Clinton signed the executive order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.* The order mandated federal agencies to incorporate environmental justice into their policies and regulations (Bullard R. D., 2005).

Commemorating the twentieth year anniversary of the 1987 report on *Toxic Wastes and Race in the United States,* the United Church of Christ commissioned a new report on environmental racism in 2007 called *Toxic Wastes and Race at Twenty*. The report uses the 2000 census data for analysis of racial connections with hazardous waste disposal. The report stated that despite introduction of several Environmental Justice programs at various levels of government, significant racial disparities still exist in

distribution of the nation's hazardous commercial waste facilities. The study found that of the 9.2 million people living in the vicinity of commercial hazardous waste facilities, 5.1 million people were of color (Bullard, Mohai, Saha, & Wright, 2007). The *Toxic Wastes and Race at Twenty* report concluded that- race is still a predominant factor in determining where commercial hazardous waste facilities are located; communities of color receive minimal attention from the government in mitigating harmful effects of hazardous wastes; various levels of government have been ineffective in responding to environmental health threats from toxic waste in communities of color; and the U.S. EPA has failed to implement the Executive Order 12898. The report recommended that new legislative changes be made to address the systemic problems of environmental degradation in low income and minority communities (Bullard, Mohai, Saha, & Wright, 2007).

4.2 EPA and Environmental Justice

EPA defines Environmental Justice as *the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies* (U.S. EPA, 2005).

In the light of recent failures in adopting EJ in governmental policies and regulations, the present EPA administrator Lisa Jackson has made EJ an Agency priority. In July 2010, EPA's Office of Environmental Justice developed the Plan EJ 2014 as part of the EPA Strategic Plan for 2011-2015 (Office of Environmental Justice, 2011). Plan EJ 2014 seeks to (Office of Environmental Justice, 2011, p. 2):

- Protect the environment and health in overburdened communities
- Empower communities to take action to improve their health and environment
- Establish partnerships with local, state, tribal, and federal governments and organizations to achieve healthy and sustainable communities

Two of the important areas of focus presented in the Plan EJ 2014 are incorporating EJ into rule making at EPA and supporting community-based action programs. The EPA also plans to advance EJ through rigorous Compliance and Enforcement. EPA administrator Lisa Jackson recognizes that *"all too often, low-income, minority and tribal Americans live in the shadows of the worst pollution, facing disproportionate health impacts and greater obstacles to economic growth in communities that cannot attract businesses and new jobs"* (Office of Environmental Justice, 2011, p. 1), and through the implementation of Plan EJ 2014 Administrator Jackson hopes to expand the conversation on environmental justice.

4.3 Environmental Justice and RE-Powering America's Land Initiative

Data regarding demographics of communities surrounding brownfields redeveloped through the RE-Powering America's Land initiative is not available. So, it cannot be determined whether the initiative has focused on developing brownfields in predominantly minority and low income areas. Though RE-Powering America's Land Initiative promises benefits to low-income and minority communities surrounding brownfields, the initiative does not mandate any policies that would directly benefit the community. There are no policies mandating creation of local jobs or distribution of produced electricity in the local area at discounted prices.

Considering the fact that minority and low income communities have felt the most adverse effect of brownfields, some of the redevelopment benefits must be directly transferred to the community as well. As part of EPA's Plan EJ 2014, EJ policies must be introduced into programs like RE-Powering America's Land which have direct relevance to minority and low income communities.

5. 95 Grand Street- A Case Study

The City of Worcester, Massachusetts has been a hub of industrial activity since the early American Industrial Revolution. It has been home to many industrial pioneers like Washburn & Moen, Crompton & Knowles and the Norton Company (now Saint-Gobain). But many of these old establishments have abandoned their properties in Worcester due to various reasons (Executive Office of Economic Development, 2011). Many of these sites fall under the category of brownfields due to contaminants leftover from decades of industrial activity. Figure 12 shows one such site at 95 Grand Street. The site housed Crompton and Knowles Co., till the 1980's. It is now abandoned and marked off as a contaminated site. This chapter relates arguments made in the previous section to the brownfield site at 95 Grand Street, Worcester, MA.

Figure 11- Proposed site for pilot project at 95 Grand Street, Worcester MA

5.1 The City of Worcester

Worcester is a city in the Worcester County of Massachusetts. According to the 2000 census, it is the third largest city in New England with a population of 172,596. It is governed by a council-manager government form (City of Worcester, 2011). Under this form of government, an elected City Council is

responsible for legislative functions. The Council appoints a professional Manager to oversee administrative operations. The position of the Mayor is mostly ceremonial.

Worcester was incorporated as a town in 1722 and became a city in 1848 (City of Worcester, 2011). The City has a bright history, being home to well-known innovators, industrialists and educators. Worcester and Blackstone Valley played a major role in the American Industrial Revolution. A pioneer industrialist, Ichabod Washburn developed a process to produce barbed wire which defended the battle lines during the World War I. George Crompton and L. J. & F. B. Knowles designed textile looms and set up factories to drive their production. John Jeppson founded the Norton Company, now known as Saint-Gobain in Worcester.

As the industrial revolution came to an end, many companies in Worcester shut down their operations and abandoned their facilities. Since then these facilities have either been converted to warehouses or deemed unfit for any usage. Many of these sites are contaminated from decades of industrial activity. To put them to proper utilization, adequate environmental cleanup is necessary. The City of Worcester has set up a $1.3 million Brownfields Cleanup Revolving Loan Fund (BCRLF) with the help of the U.S. Environmental Protection Agency (EPA) and provides low-interest loans to for-profit and non-profit agencies for environmental cleanup of brownfields (Executive Office of Economic Development, 2011).

5.2 Main South Community

As shown in Figure 13, Main South is a neighborhood located around the Main Street in southern Worcester. Between 1890s and 1950s, the Main South area experienced rapid economic development and many industrial ventures were setup in the area. Notably, the Worcester Corset Company was built at 30 Wyman Street in 1895 and Crompton and Knowles Loom Works was established at 95 Grand Street in 1897. Both these companies and many others abandoned their operations in Worcester in the 1980s (Rushford, 2011). Today, the Main South community is riddled with a number of potentially contaminated abandoned industrial sites or brownfields.

The Main South community mainly comprises of low income, minority households. As shown in Figure 14, according to the 2000 census, about 56% of the community belongs to a race of color. 23.3% of the community lives below poverty line (Main South Community Development Corporation, 2000) and the estimated median family income in 2011 was $43,288 (Federal Financial Institutions

Examination Council , 2011) while that of the City of Worcester was $79,700 (Executive Office of Economic Development, 2011).

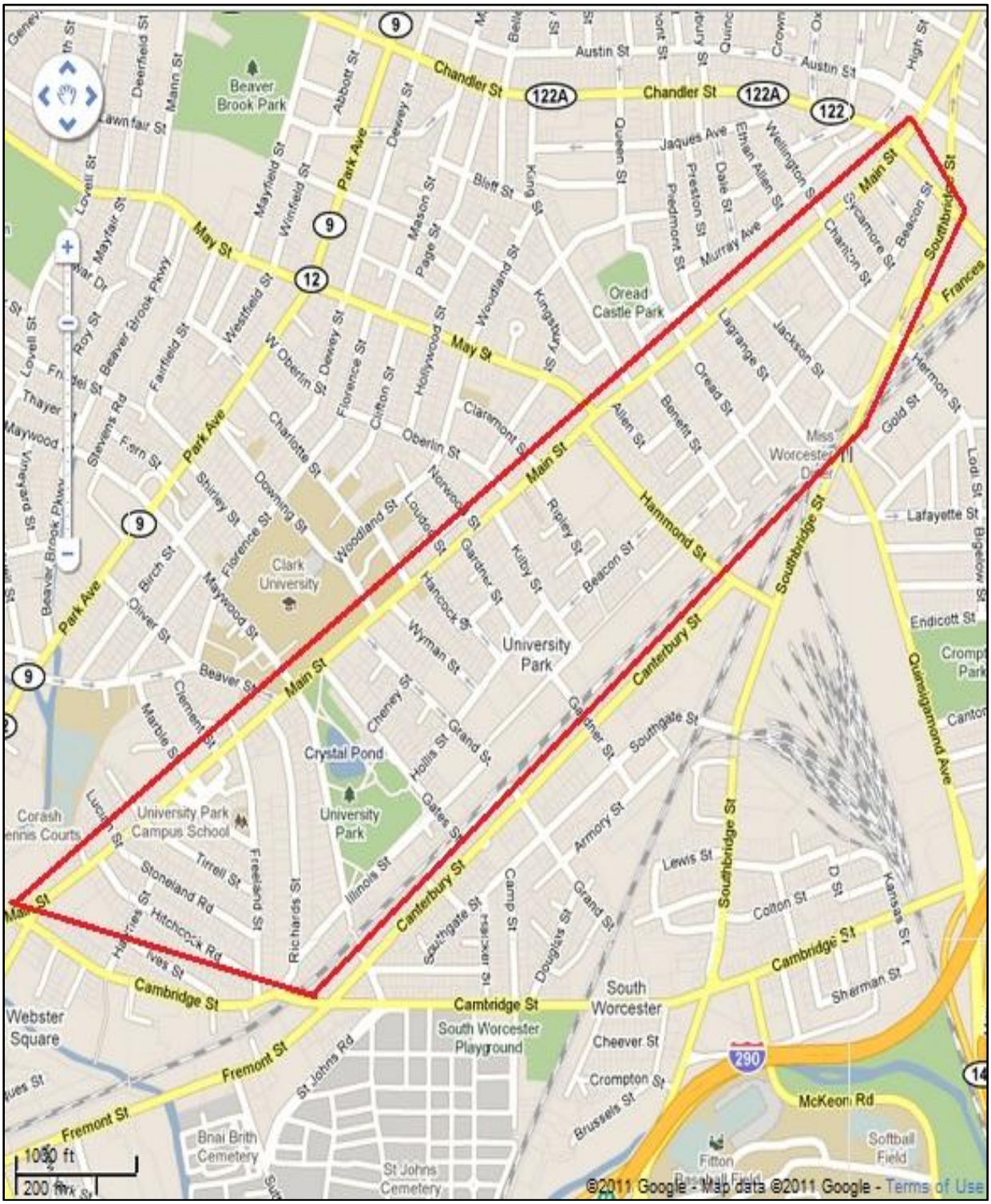

Figure 12- Map showing the Main South area in the city of Worcester, MA
Source: Google Maps

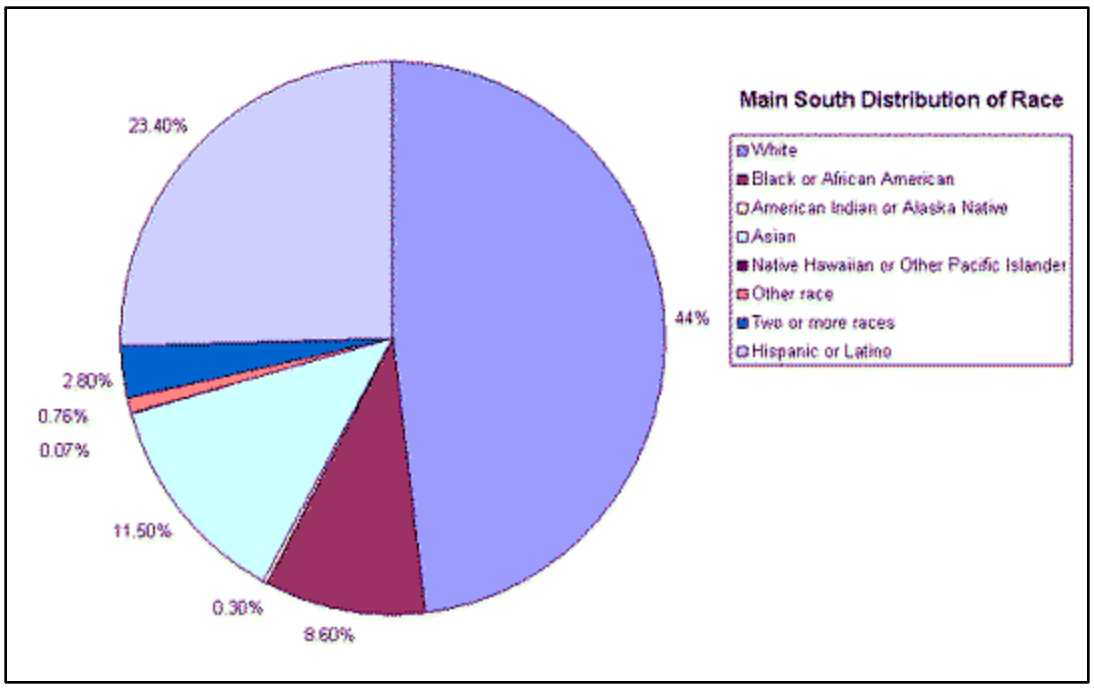

Figure 13- Distribution of race in Main South community
Source: Main South Community Development Corporation

Main South Community Development Corporation (Main South CDC) has been striving to improve the quality of life in this area since 1986. The mission statement of Main South CDC emphasizes "creating affordable housing for low-to-moderate income individuals, support economic opportunities for businesses and residents of Main South and enhance the physical image of the area" (Main South CDC, 2010). Most of the Main South CDC's projects directly deal with revitalization of brownfields. Some of the projects that the Main South CDC has undertaken are:

1. Kilby-Gardner-Hammond Neighborhood Revitalization Project

   A private-public partnership project which resulted in construction of a Boys and Girls Club, athletic facilities for Clark University Worcester and affordable housing on remediated brownfields

2. Beacon-Oread Street Revitalization Project

   A project that resulted in the physical transformation of a one-block area devastated by fire and led to the construction of a 34 unit affordable housing complex

3. Loom Works Development Project

   A planned project to revitalize abandoned mill structures at 93 Grand Street and convert them to an artist's district with shops and accommodation for artists

5.3 95 Grand Street

95 Grand Street housed Crompton and Knowles Loom Works from 1897 to the 1980's. It has been abandoned since the 1980's when the company split and relocated to Middlebury, CT (WorcesterMass.com, 2007). 95 Grand Street stills houses old mill structures dating back to 1897. The principle contaminant on the site is heating oil leaking from an underground storage tank (Homefacts.com, 2011). The mill structure also has some part of the roof collapsing. Due to contamination of the site, any redevelopment plan needs to be preceded by an extensive environmental cleanup. According to the 2009 Brownfields Redevelopment Fund report by MassDevelopment, a sum of $47,245 has been granted to Ralphco Inc. for environmental assessment of the brownfield site (MassDevelopment, 2009).

The 95 Grand Street property is currently owned by the City of Worcester. The total lot area is about 2.44 acres and in 2010 it was valued at $206,700. This was a 33.58% decrease from the initial valuation of $276,100 (City of Worcester, 2010). The building itself is structurally weak and the roof is caving in at places. Figure 15 shows the satellite aerial view of the site. Figure 16 shows the street map of the site. It can be observed that the site is located right next to a set of railway tracks. Figure 17 shows the front view of the building. The white and red cross marks on the building indicate contamination of the building.

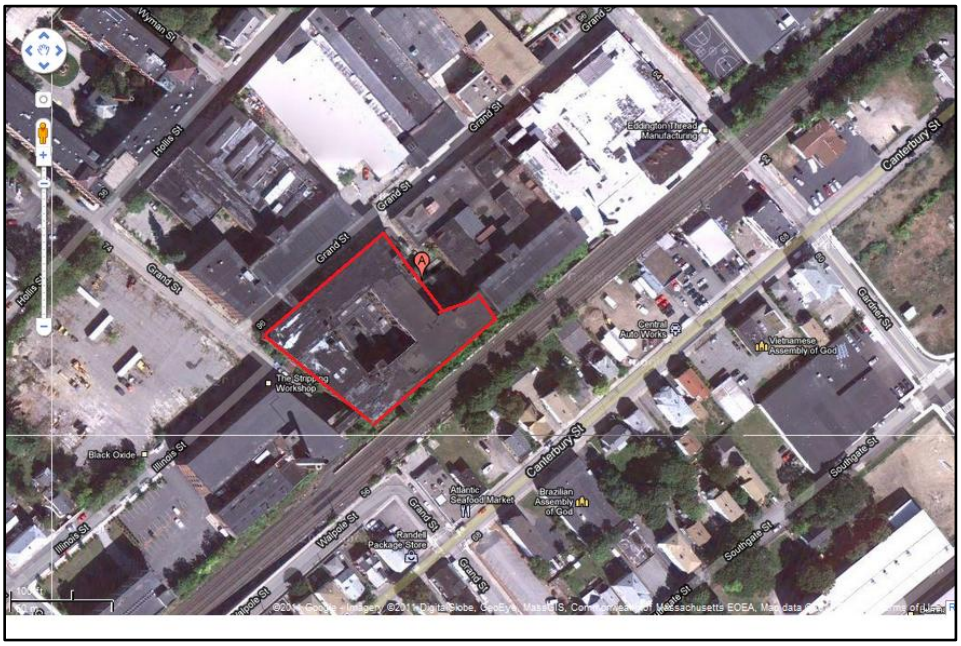

Figure 14- Aerial view of 95 Grand Street
Source: Google Earth

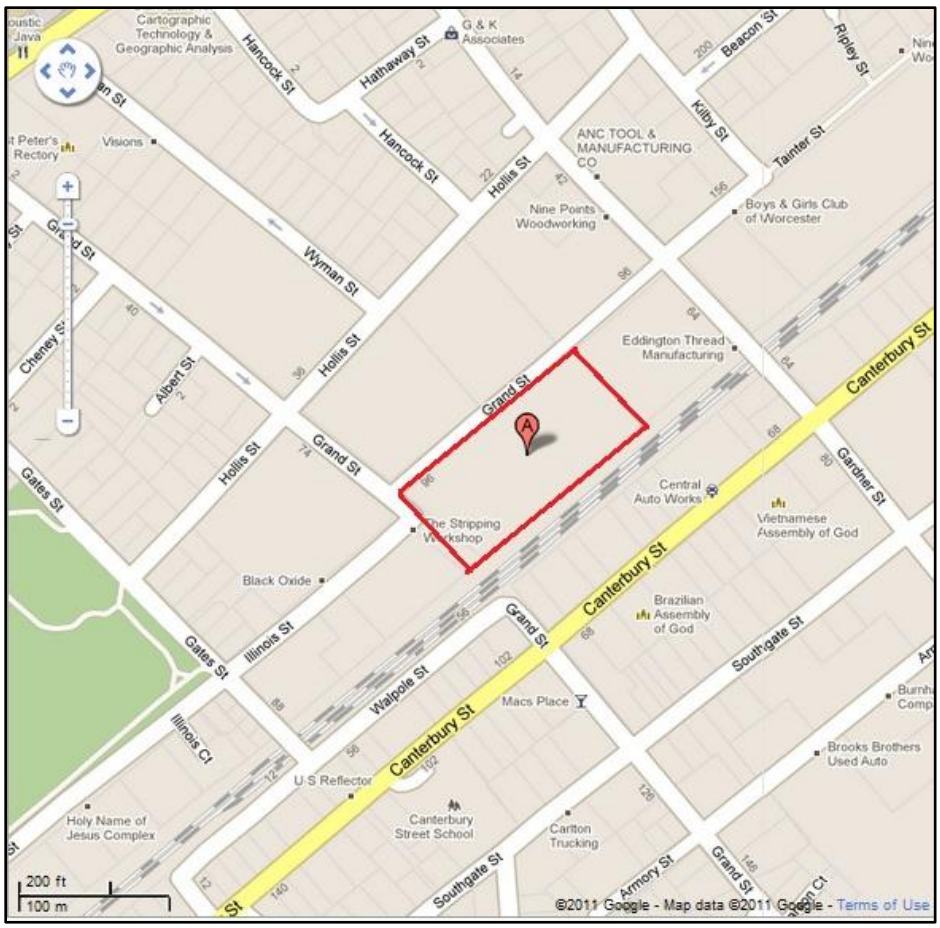

Figure 15- Street map of 95 Grand Street
Source: Google Maps

Figure 16- Front side view of 95 Grand Street

5.4 Redevelopment Plan for 95 Grand Street

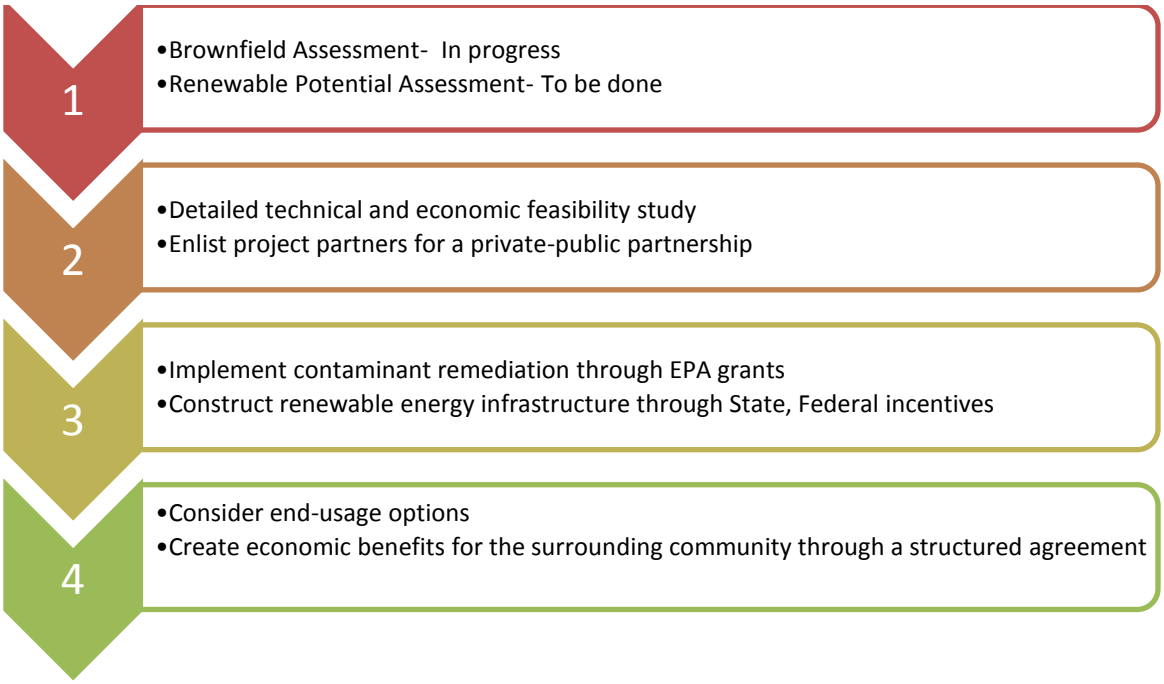

Figure 17- Chart showing the redevelopment plan for the brownfield site at 95 Grand Street, Worcester MA

5.4.1 Site Assessment

Site assessment of 95 Grand Street, Worcester should determine the following:

1. *Brownfield Assessment*- Brownfield Assessment identifies and quantifies the contaminants present on the site, and devices appropriate methods to remove the contaminants and remediate the site
2. *Renewable Potential Assessment*- Renewable Potential Assessment identifies the appropriate renewable energy source for the site and identifies the appropriate technology to exploit the renewable energy source

Available Data:

1. The site contains leaking underground storage tanks spilling heating oil and the roof of the structure is caving in at places (Homefacts.com, 2011)
2. Ralphco Inc. has been given a grant of $47,245 for the brownfield assessment
3. A brownfield site at 65 Tainter Street, Worcester MA (a block away from 95 Grand Street, Worcester, MA) has been analyzed by NREL under the RE-Powering America's Land program and

is reported to have potential for non-grid connected photovoltaic or geothermal heat pump installations (National Renewable Energy Laboratory, 2011)

Action Steps: Apply for the RE-Powering America's Land initiative's Renewable Energy Feasibility Study

Useful Resources: RE-Powering America's Land initiative has developed a Solar Decision Tree in collaboration with NREL to screen a brownfield site for solar energy potential. A draft of the Solar Decision Tree can be found on the RE-Powering America's Land website (http://www.epa.gov/oswercpa/docs/solar_decision_tree.pdf)

5.4.2 Feasibility Analysis

A feasibility analysis of siting renewable energy on 95 Grand Street will determine the technical and economic feasibility of the project. The analysis will take into account the cleanup costs, cost of renewable energy infrastructure, size of the system, operating costs, available financial incentives and sell-back price of electricity to the grid to determine profitability of the project. The RE-Powering America's Land initiative can help in this process.

At this stage it is important to enlist project partners for a public-private partnership. Some of the potential project partners are the City of Worcester, National Grid, Main South Community Development Corporation, Worcester Business Development Corporation and some private renewable energy developers like Future Solar Systems LLC.

Action Steps: Determine technical and economic feasibility of the project and recruit partners

Useful Resources:

- Massachusetts State Financial Incentives Fact Sheet available on the RE-Powering America's land website (http://www.epa.gov/oswercpa/incentives/ma_incentives.pdf)
- The City of Worcester has set a Brownfield Cleanup Revolving Loan Fund to provide small grants and low-interest loans for cleanup of brownfields (http://www.worcestermass.org/land-development-in-worcester/brownfield-cleanup-revolving-loan-fund-bcrlf)

5.4.3 Implementation

When technical and economic feasibility of the project is established and finances are procured, implementation of the project can start. Renewable energy infrastructure can be built as cleanup is on-

going and the energy generated can be used to finish the cleanup process. It is important to involve the local community and create local jobs during the implementation stage.

5.4.4 Post-completion Considerations

After completion of the project, it is important to consider sustainable options for end-usage. End-usage must be equally focused on profitability and community needs, as discussed in chapter 4. Utilizing tools like net metering, renewable portfolio standards and renewable energy certificates will be vital to the success of a renewable energy project on 95 Grand Street.

The following mechanisms can be employed to ensure that the low income and minority communities surrounding the brownfield at 95 Grand Street receive benefits from a redevelopment project, as well providing returns for a project developer's investment:

1. Long term power purchase agreements - An agreement can be made between the community and the project developer, wherein the community promises to purchase electricity from the generating facility at 95 Grand Street over a specified term at a lowered fixed price. An agreement like this safeguards the community against rising electricity costs and provides a stable, predictable source of income for the project developer.
2. An agreement can also be made mandating the project developer to distribute a share of the electricity produced on 95 Grand Street in the surrounding community depending on the percentage of financial aid received against total cost of the project. For example, if a project developer received 50-60% of the total project costs in form of financial incentives from state, federal or regional governments, the developer can be mandated to provide the surrounding community at least 25% of the total electricity produced at the site at half the market price. The example is for illustrative purposes only and a through scientific analysis must be done while designing a framework for this mechanism, taking into account both profitability for the developer and community needs.

6. Summary and Conclusions

The demand for electricity has grown considerably over the last few decades placing the U.S. electric power grid under tremendous stress. The grid has shown minimum growth since the 1960s and the future of the grid is a concern to many experts. Experts have analyzed topics of reliability, security, efficiency and sustainability; and have concluded that the U.S. electric power grid needs a major structural overhaul (Electricity Advisory Committee, 2008). Fixing the current problems with the grid and modernizing it for future sustenance is essential for national security, environmental integrity and economic growth.

The U.S. Department of Energy (DOE) and many other organizations have been proactively working to find solutions to problems faced by the grid. The problems are being tackled with a multi-faceted approach combining policy changes with technological advancements. There is general consensus among experts that development of renewable energy is a vital part of the solution to current energy problems (Tester, 2005). Policies like the Energy Independence and Security Act of 2007, Renewable Portfolio Standards and Net Metering have been enacted to promote electricity generation from renewable sources. The DOE is progressively investing in new renewable energy based generation facilities. Wind and solar energy have been given prominence while planning future addition to electricity generation capacity. Figure 10 shows the planned generation capacity addition by energy source for 2011, 2012 and 2014. It is clear that coal is being phased out as the primary energy source for electricity generation and the offset is being filled by renewable sources (Energy Information Administration, Electric Power Annual 2010, 2011).

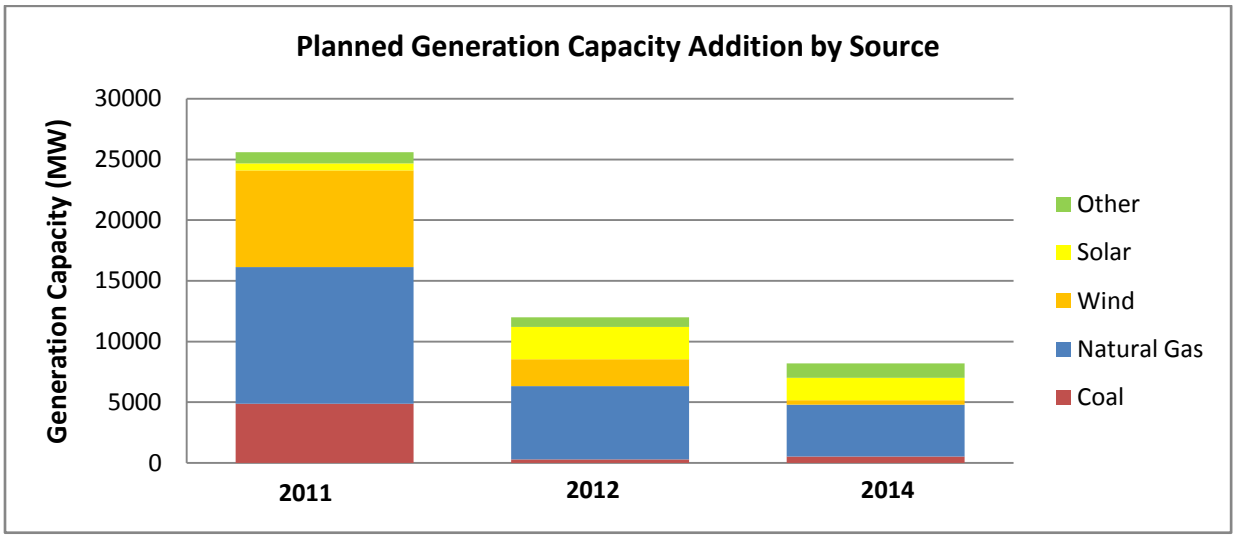

Figure 18- Chart showing the planned generation capacity addition by source for 2011, 2012 and 2014 **(EIA, 2011)**

Development of renewable energy on a large scale faces an important challenge. Electricity generation from renewable sources tends to be capital intensive. There is a burden of heavy initial investment on generation infrastructure, which is being offset by federal and state incentive programs and there is a problem of lack of appropriate space to site the infrastructure, especially in cities. Abandoned industrial sites, i.e. brownfields which are otherwise unusable offer inexpensive real estate and have been thought of as a solution to the problem of space (Environmental Protection Agency, 2001). Siting electricity generating facilities on brownfields in turn is a good way to remediate the contaminated sites.

A brownfield site is defined as *real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant* (107th Congress, 2002, p. 115). The U.S. Environmental Protection Agency (EPA) has tracked more than 450,000 brownfield sites across the nation accounting for billions of acres of unusable land. Redevelopment of these contaminated sites offers many economic and environmental benefits to both investors and the community.

EPA has been instrumental in framing effective brownfields redevelopment policies and programs since 1995. In 2002, EPA's brownfield policies were passed into law by the Small Business Liability Relief and Brownfields Revitalization Act. The Act provided Superfund liability relief to entities interested in redeveloping contaminated areas. Since the introduction of the Small Business Liability Relief and Brownfields Revitalization Act, EPA has sought to rigorously promote redevelopment and reuse of brownfields. As a part of EPA's efforts in brownfield revitalization, RE-Powering America's Land initiative was launched in 2008 to encourage siting renewable energy resources on contaminated sites.

Through the RE-Powering America's Land initiative, EPA in collaboration with the National Renewable Energy Laboratory (NREL) provides technical assistance to entities interested in developing renewable energy on brownfield sites. The technical assistance includes but not limited to-

- determining the right renewable energy source for a site
- assessing the renewable energy potential of the site
- determining the appropriate power generation technology to use
- designing optimal placement of the generation technology
- analyzing economic potential of the project
- addressing cleanup and liability issues

Several projects have been successfully completed under the RE-Powering America's Land initiative. An analysis of successful projects shows that the end-use of each project is different and depends on a variety of factors. Some projects locally utilize the electricity produced while others sell electricity to the grid at a lowered price. RE-Powering America's land initiative does not have any policies governing end-usage.

When Environmental Justice is taken into consideration, end-use policies in the RE-Powering America's Land initiative are essential, especially in low income and minority communities. Low income and minorities communities have been most affected by hazardous waste in contaminated properties and when redeveloping the contaminated properties, benefits of the redevelopment must be shared with the surrounding community. Some mechanisms for distributing benefits of a RE-Powering America's Land project in the surrounding community are as follows:

1. Long term power purchase agreements with the project developers promising supply of electricity at a fixed lowered price
2. Mandates to provide discounted electricity to the community depending on the percentage of financial incentives received from the government in the total cost of the project

A general outline for a renewable energy development project on 95 Grand Street Worcester, MA has been provided in chapter 5. Future project groups can focus their work on the action steps mentioned section 5.4.4.

7. References

Public Law 107-118 (H.R. 2869). (2002). *Small Business Liability Relief and Brownfields Revitalization Act.*

107th Congress. (2002). *Small Business Liability Relief and Brownfields Revitalization Act.* Washington D.C.: Librray of Congress.

107th Congress. (2002). *Small Business Liability Relief and Brownfields Revitalization Act of 2002.* Washington D.C.: Library of Congress.

109th Congress. (2005). *Energy Policy Act.* Washington D.C.: Library of Congress.

110th Congress. (2007, Dec 19). *Public Law 110-140.* Retrieved from The Library of Congress: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ140.110.pdf

Abrams, R. H. (1997). Superfund and the Evolution of Brownfields. *William & Mary Environmental Law and Policy Review , 21* (1).

Alanne, K., & Saari, A. (2004). *Distributed Energy Generation and Sustainable Development.* Elsevier.

American Society of Civil Engineers. (2009). *2009 Report Card for America's Infrastructure.* American Society of Civil Engineers.

Amin, S. M. (2011, January). U.S. Electrical Grid Gets Less Reliable. *IEEE Spectrum* .

Brodsky, B. (2007). *Environmental Justice.* University of Texas, Austin.

Bullard, R. D. (2005). *The Quest for Environmental Justice- Human Rights and the Politics of Pollution.* Sierra Club Books: San Francisco.

Bullard, R., Mohai, P., Saha, R., & Wright, B. (2007). *Toxic Waste and race at Twenty.* United Church of Christ.

Bush, G. (2007). *State of the Union*. Retrieved from The White House: http://georgewbush-whitehouse.archives.gov/stateoftheunion/2007/initiatives/energy.html

California Energy Commission. (2004, October). *Background*. Retrieved from California Distributed Energy Resource Guide: http://www.energy.ca.gov/distgen/background/background.html

Canadian Institute for Environmental Law and Policy. (2011). *What are the risks to developing brownfields?* Retrieved December 18, 2011, from Brownfield Redevelopment: What You Should Know: http://www.cielap.org/brownfields/risks.html

Carley, S. (2009). *State renewable energy electricity policies: An empirical evaluation of effectiveness.* Energy Policy.

Center for Climate and Energy Solutions. (2009). *Green House Gas Emissions by Sector*. Retrieved from Center for Climate and Energy Solutions: http://www.c2es.org/facts-figures/us-emissions/sector

Center for Program Analysis. (2010). *RE-Powering America's Land Initiative- Management Plan.* U.S. EPA.

Center for Program Analysis. (2009). *Siting Renewable Energy on Potentially Contaminated Land and Mine Sites.* U.S. EPA.

City of Worcester. (2011). *History, Trivia, Vital Stats & More!* Retrieved 02 28, 2011, from Worcester MA: http://www.worcesterma.gov/city-clerk/history

City of Worcester. (2010, 01 01). *Property Value Details*. Retrieved 02 28, 2011, from worcesterMA: http://www.worcesterma.gov/e-services/search-public-records/property-values/property-values-details?field1=f1d4004c-14fb-11e0-887d-001a64c29c6c

City of Worcester. (2011). *Quick Facts*. Retrieved November 29, 2011, from WorcesterMA.gov: http://www.worcesterma.gov/quick-facts

Commonwealth of Massachusetts. (2011, December). *Net Metering Frequently Asked Questions and Answers*. Retrieved from mass.gov: http://www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/agencies-and-divisions/dpu/net-metering-faqs.html#one

Commonwealth of Massachusetts. (2011, November). *RPS and APS Program Summaries.* Retrieved from mass.gov: http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/rps-aps/rps-and-aps-program-summaries.html

Community Reinvestment Forum. (2003). *The Community Redevelopment Act: A Growing Tool for Brownfield Redevelopment.* The Federal Reserve Bank of Cleveland.

Department of Interior. (2011, November). *Hydopower at Hoover Dam*. Retrieved from U.S. Departmemt of Interior: http://www.usbr.gov/lc/hooverdam/faqs/powerfaq.html

DOE-EERE. (2011, May). *Green Power Markets*. Retrieved from Energy Efficiency and Renewable Energy: http://apps3.eere.energy.gov/greenpower/markets/netmetering.shtml

DOE-EERE. (2009, June). *States with Renewable Portfolio Standards*. Retrieved from Energy Efficiency and Renewable Energy: http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm

Dominion. (2011, Nov). *Brayton Point Power Station*. Retrieved from Dominion: http://www.dom.com/about/stations/fossil/brayton-point-power-station.jsp

DSIRE. (2011, December). *California - Net Metering* . Retrieved from DSIRE: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA02R

DSIRE. (2011, December). *Connecticut- Net Metering*. Retrieved from DSIRE: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CT01R&re=1&ee=0

DSIRE. (2011, December). *Financial Incentives for Renewable Energy.* Retrieved from DSIRE: http://www.dsireusa.org/summarytables/finre.cfm

DSIRE. (2011, November). *RPS Data Spreadsheet.* Retrieved from DSIRE: http://www.dsireusa.org/rpsdata/index.cfm

Electricity Advisory Committee. (2008). *The Smart Grid: An Introduction.* Washington DC: Department of Energy.

Energy Information Administration. (2008). *Annual Electric Generator Report.* U. S. Energy Information Administration.

Energy Information Administration. (2010). *Annual Energy Outlook.* U.S. Energy Information Administration.

Energy Information Administration. (2008). *Data- Total Energy*. Retrieved from U.S. Energy Information Administration: https://spreadsheets.google.com/spreadsheet/pub?key=0Ajz-a2-Ol22KdE5UT3U3U1FubHM2eWNEOVlPelVEcHc&gid=3

Energy Information Administration. (2011). *Electric Power Annual 2010.* U.S. Energy Information Administration.

Energy Information Administration. (2011). *Electric Power Monthly- August 2011.* EIA.

Energy Information Administration. (2009, October 20). *Energy in Brief*. Retrieved from http://www.eia.gov/energy_in_brief/power_grid.cfm

Energy Information Administration. (2011). *Frequently Asked Questions*. Retrieved from U.S. Energy Information Administration: http://205.254.135.24/tools/faqs/faq.cfm?id=104&t=21

ENERGYliteracy.com. (2011, Nov). *Historical US electricity production, by generation source, and consumption by sector*. Retrieved from www.energyliteracy.com: http://www.energyliteracy.com/?p=142

Environmental Law Institute. (2011). *Brownfields Basics*. Retrieved December 2011, from Brownfields Center: http://www.brownfieldscenter.org/big/bfbasics.shtml

Environmental Protection Agency. (2001, October). *Basic Information*. Retrieved from EPA Brownfields and Land Revitalization: http://www.epa.gov/brownfields/

EPA. (2009). *Success Stories and Case Studies on Siting Renewable Energy on Contaminated Land and Mine Sites*. Retrieved December 28, 2011, from RE-Powering America's land: http://www.epa.gov/oswercpa/successstories.htm#casper

EPA, NREL. (2011). *Screening Sites for Solar PV Potential.* U.S. EPA.

Executive Office of Economic Development. (2011). *About Worcester*. Retrieved November 29, 2011, from City of Worcester, Massachusetts: http://www.worcestermass.org/about-worcester

Executive Office of Economic Development. (2011). *Brownfield Cleanup Revolving Loan Fund (BCRLF)*. Retrieved November 29, 2011, from City of Worcester, Massachusetts: http://www.worcestermass.org/land-development-in-worcester/brownfield-cleanup-revolving-loan-fund-bcrlf

Executive Office of Energy and Environmental Affairs. (2010). *Annual RPS Compliance Report of 2008.* Commonwealth of Massachusetts.

Federal Financial Institutions Examination Council . (2011). *2011 FFIEC Census Report - Summary Census Demographic Information.* Federal Financial Institutions Examination Council .

FFIEC. (2009, November 11). *Background & Purpose*. Retrieved December 18, 2011, from Community Reinvestment Act: http://www.ffiec.gov/cra/history.htm

Heinberg, R. (2008, May 28). Coal in the United States. *Energy Bulletin* .

Homefacts.com. (2011). *95 Grand St Worcester Environmental Hazards*. Retrieved June 9, 2011, from Homefacts: http://www.homefacts.com/realestatearea/environmentalhazards/Massachusetts/Worcester-County/Worcester/95-Grand-St.html

IEEE. (2003, August). *Darkness Falls: A Timeline of the Blackout of 2003*. Retrieved from IEEE Spectrum: http://spectrum.ieee.org/energy/the-smarter-grid/darkness-falls-a-timeline-of-the-blackout-of-2003

indexmundi. (2011, November). *Commodity Prices*. Retrieved from indexmnundi: http://www.indexmundi.com/commodities/

Institute of Electrical and Electronics Engineers. (2011, Nov). *Milestones:Adams Hydroelectric Generating Plant, 1895*. Retrieved from IEEE Global History Network: http://www.ieeeghn.org/wiki/index.php/Milestones:Adams_Hydroelectric_Generating_Plant,_1895

International Energy Agency. (2009, May 13). *Press Releases*. Retrieved from International Energy Agency: http://iea.org/press/pressdetail.asp?PRESS_REL_ID=284

International Energy Agency. (2010). *Projected Costs of Generating Electricity.*

Lammers, H. (2011, December 11). *New Lab to Help Utilities "See" Grid of the Future*. Retrieved from RenewableEnergyWorld.com: http://www.renewableenergyworld.com/rea/news/article/2011/12/new-lab-to-help-utilities-see-grid-of-the-future

Lawrence Liverpool National Laboratory. (2009). *Estimated U.S. Energy Use in 2009.* Department of Energy.

Main South CDC. (2010). *Mission Statement*. Retrieved June 5, 2011, from Main South Community Development Corporation: http://www.mainsouthcdc.org/missionstatement.php

Main South CDC. (n.d.). *Poverty Rates according to the US census*. Retrieved 02 2011, 28, from http://www.mainsouthcdc.org/poverty_rate.php

Main South Community Development Corporation. (2000). *Poverty Rates according to the US census*. Retrieved 02 28, 2011, from Main South Community Development Corporation: http://www.mainsouthcdc.org/poverty_rate.php

Massachusetts Department of Public Utilities. (2011, February). *Docket 11-10.* Retrieved from Massachusetts DTE: http://db.state.ma.us/dpu/qorders/frmDocketSingle.asp?docknum=11-10

MassDevelopment. (2009). *Brownfields Redevelopment Fund.* MassDevelopment.

Matthews, L. (2011). *US EPA RE-Powering Feasibility Studies.* U.S. Environmental Protection Agency.

Matthews, L. (2011). *US EPA RE-Powering Feasibility Studies- 2011 Request for Applications (RFA).* U.S. EPA.

Minkel, J. (2008, August 13). The 2003 Northeast Blackout--Five Years Later. *Scientific American* .

Morgan, J. (2010, 04 02). Retrieved 02 15, 2011, from Nuclear Fissionary: http://nuclearfissionary.com/2010/04/02/comparing-energy-costs-of-nuclear-coal-gas-wind-and-solar/

National Academy of Engineering. (2003). *A Century of Innovation: The Engineering That Transformed Our Lives.* Joseph Henry Press.

National Academy Press. (1986). Electricity in Economic Growth.

National Public Radio. (2009). *Visualizing the U.S. Electric Grid*. Retrieved from National Public Radio: http://www.npr.org/templates/story/story.php?storyId=110997398

National Renewable Energy Laboratory. (2011, November 4). *Data Information.* Retrieved December 21, 2011, from RE-Powering America's Land: http://www.epa.gov/oswercpa/data.htm

National Resources Defense Council. (n.d.). Retrieved 02 15, 2011, from http://www.nrdc.org/energy/renewables/solar.asp

NationMaster. (2008). *Electricity Consumption by Country*. Retrieved from NationMaster: http://www.nationmaster.com/graph/ene_ele_con-energy-electricity-consumption

Nuclear Fissionary. (2008). *Cost of Electricity Production*. Retrieved from Nuclear Fissionary: http://nuclearfissionary.com

Office of Brownfields and Land Revitalization. (2011). *Brownfields Training, Research, and Technical Assistance (K6) Grants.* U.S. EPA.

Office of Brownfields and Land Revitalization. (2011). *Environmental Workforce Development and Job Training.* U.S EPA.

Office of Environmental Justice. (2011). *Plan EJ 2014.* Washington D.C.: U.S. EPA.

Office of Solid Waste and Emergency Response. (2009). *EPA Brownfields Assessment Grants: Interested in Applying for Funding?* EPA.

Office of Solid Waste and Emergency Response. (2007). *EPA Targeted Brownfields Assessments—The Basics.* U.S. EPA.

Pepermans, G., Driesen, J., Haeseldonckx, D., Belmans, R., & D'haeseleer, W. (2005). *Distributed generation: Definition, benefits and issues.* Energy Policy.

Rhode Island Department of Environmental Management. (2003, April). *Advantages of Brownfield Redevelopment*. Retrieved December 2011, from Reinvesting in Rhode Island's Brownfields: http://www.dem.ri.gov/brownfields/why.htm

Rushford, D. (2011). *Historical Highlights of Worcester.* Worcester: City of Worcester, MA.

Shannon, K. (2010, Spetember 9). *China Overtakes The US In Total Renewable Energy Investments.* Retrieved from DailyMarkets: http://www.dailymarkets.com/stock/2010/09/09/china-overtakes-the-us-in-total-renewable-energy-investments/

Sissine, F. (2007). *Energy Independence and Security Act of 2007: A Summary of Major Provisions.* Washington D.C.: Congressional Research Service.

Tester, J. W. (2005). *Sustainable Energy: Choosing Among Options.* MIT Press.

The World Bank. (2010). *World Development Indicators*. Retrieved November 2011, from The World Bank: http://data.worldbank.org/country/united-states?display=graph

Tverberg, G. E. (2008). The U. S. electric grid: will it be our undoing? *Energy Bulletin* , 1-3.

U.S. Environmental Protection Agency. (2011, December 29). *Brownfields Area-Wide Planning Pilot Program*. Retrieved December 30, 2011, from epa.gov: http://epa.gov/brownfields/areawide_grants.htm

U.S. Environmental Protection Agency. (2011). *Brownfields Program Accomplishments.* U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. (2011). *Brownfields Tax Incentive Fact Sheet.* Washington D.C.: U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. (2011, December 12). *CERCLA Overview*. Retrieved December 18, 2011, from Environmental Protection Agency: http://www.epa.gov/superfund/policy/cercla.htm

U.S. Environmental Protection Agency. (2011). *Community Reinvestment Act (CRA) Fact Sheet.* U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. (2011). *EPA Brownfields Program Benefits.* The U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. (2011, November 29). *Renewable Energy Interactive Mapping Tool*. Retrieved December 28, 2011, from RE-Powering America's Land: http://www.epa.gov/oswercpa/mapping_tool.htm

U.S. Environmental Protection Agency. (2009). *RE-Powering America's Land- Fact Sheet.* U.S. EPA.

U.S. Environmental Protection Agency. (2011). *RE-Powering America's Land: Mapping Tools.* U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. (2011, December 12). *SARA Overview*. Retrieved December 18, 2011, from Environmental Protection Agency: http://www.epa.gov/superfund/policy/sara.htm

U.S. Environmental Protection Agency. (2011). *Summary of the Small Business Liability Relief and Brownfields Revitalization Act.* U.S. Environmental Protection Agency.

U.S. Environmetal Protection Agency. (2011, October 4). *Basic Information*. Retrieved December 19, 2011, from Brownfields and Land Revitalization: http://epa.gov/brownfields/basic_info.htm

U.S. EPA. (2005). *Basic Information*. Retrieved from Environmental Justice: http://www.epa.gov/compliance/environmentaljustice/basics/index.html

United Church of Christ. (1987). *Toxic Wastes and Race in the United States.* New York: Commission for Racial Justice.

Wikipedia. (2011). *Brownfield Land.* Wikipedia.

Wikipedia. (2011, Nov). *Edison Illuminating Company*. Retrieved from www.wikipedia.org: http://en.wikipedia.org/wiki/Edison_Illuminating_Company

WorcesterMass.com. (2007, October 13). *Places of the Past, Crompton and Knowles Loom Works*. Retrieved June 6, 2011, from WorcesterMass.com: http://www.worcestermass.com/places/cromption.shtml

World Bank. (2008). *Electric Power Consumption perCapita*. Retrieved from World Bank: Indicators: http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC

World Bank. (2011, November). *World Development Indicators*. Retrieved from The World Bank: http://data.worldbank.org/indicator/EG.ELC.PROD.KH/countries/US?display=graph